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Habitat use home range and movements of bobcats in western Montana

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HABITAT USE, HOME RANGE, AND MOVEMENTS OF

BOBCATS IN WESTERN MONTANA

By

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ABSTRACT

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Habitat use, home range, and general movement patterns of bobcats (Felis rufus) in a coniferous forest environment were investigated from January 1980 to December 1982 as part of a 5-year bobcat ecology study in western Montana. A total of 488 radio-locations from 8 collared bobcats indicated an adult average home range size of 88.2 km2 for females and 63.0 km2 for males. During summer, adult females were most sedentary because of reproductive constraints. Dispersing individuals moved extensively, apparently in search of a suitable vacant area in which to establish a home range. Preferred bobcat habitat consisted of an extensive coniferous overstory with a dense vegetative understory of either shrubs or a combination of forbs and grasses. These habitats may have been selected because of the concealment cover necessary for hunting success. Steep, rocky habitats were most important in summer, apparently because they provided secure den sites necessary for reproductive success. Five Canada lynx (Felis lynx) were instrumented to evaluate interspecific competition between the 2 species. No direct interactions were observed, but species separation was believed to be maintained through differences in habitat preference and a possible scent-oriented avoidance system.

ACKNOWLEDGEMENTS

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Special thanks goes to Ginger Schwarz who furnished budgetary expertise that kept the project afloat when things got tight.

Last but not least, I express my most sincere thanks to my parents, my good friend Tim Fraley, and especially my wife, Bonnie, for the love and understanding which pulled me through a tragic personal crisis. Without them all else was of little importance.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

INTRODUCTION

Before the 1970's, relatively little interest was expressed over the status of the bobcat in the United States. This was due primarily to the predator or nuisance animal classification given bobcats by most states. During the 1970's, changes in the population status of exotic spotted cats, and in laws and an international convention governing trade in their fur, produced a significant increase in the economic value of the bobcat. Increasing pelt prices and rising public concern for bobcat population levels, increased pressures to establish bobcat management programs. In response, many states reclassified the bobcat as a furbearer or game animal. However, game managers, especially in the West, were faced with inadequate biological information to use in managing the species. In Montana, the 1977 reclassification of the bobcat to furbearer status produced similar information needs.

Few accounts of bobcat ecology in the western states occur in the literature. Bailey (1972, 1974) primarily investigated the social organization in bobcats of southern Idaho; Brittell et al. (1979) investigated food habits, population dynamics, and movements of bobcats in Washington; and Gashwiler et al. (1960) conducted food habit studies in Utah and Nevada. In Montana, only Robinson and Grand (1958) and Knowles (1981) reported on bobcat ecology. These researchers worked solely in Montana's eastern prairie environments. Essentially no ecological information was available on bobcats in the coniferous forests of western Montana.

To provide this information, a 5-year bobcat ecology research project was initiated in western Montana in 1980. This is the first in a series of studies designed to provide baseline management information for game managers. Objectives of this study were to:

1. determine habitat use;
2. determine home range size; and
3. describe the general movement patterns of bobcats in relation to the existing habitat characteristics of a coniferous forest environment.

STUDY AREA

Because of serious difficulties encountered in locating and capturing bobcats, the study area consisted of 3 widely separated areas in western Montana. The first encompassed the entire Garnet Mountain Range, the second was the Fish Creek drainage, and the third was near the town of Thompson Falls.

Similar mammalian and avian species made up the faunal composition of each study area. Big game populations consisted primarily of elk (Cervus elaphus), mule deer (Odocoileus hemionus), whitetail deer (O. virginianus), and a few moose (Alces alces). In the Thompson Falls area, bighorn sheep (Ovis canadensis) occupied the steep, rocky areas along the lower Thompson River. Smaller prey species commonly found were the snowshoe hare (Lepus americanus), mountain cottontail (Sylvilagus nuttallii), Columbian ground squirrel (Spermophilus columbianus), pine squirrel (Tamiasciurus hudsonicus), deer mouse (Peromyscus maniculatus), voles (Microtus spp.), bushytail woodrat (Neotoma cinerea), porcupine (Erethizon dorsatum), blue grouse (Dendragapus obscurus), spruce grouse (D. canadensis), and ruffed grouse (Bonasa umbellus). Hares and cottontails have been the most commonly reported prey species of bobcats throughout its range (Pollack 1951; Progulske 1955; Gashwiler et al. 1960; Bailey 1972,1979; Berg 1979; Buttrey 1979; and Kitchings and Story 1979). Major carnivore species were coyote (Canis latrans), black bear (Ursus americanus), marten (Martes americana), ermine (Mustela erminea), long-tailed weasel

(*M. frenata*), mink (*M. vison*), striped skunk (*Mephitis mephitis*), and mountain lion (*Felis concolor*).

Topography, climate, and vegetation vary, so each area was described separately. Description of climatic conditions for each area were based on climatological data from nearby weather stations between January 1980 and December 1982 (U.S. Climatological Bulletins). Average monthly low and high temperatures generally occurred in January and July, and most of the annual precipitation fell between December and May.

Garnet Mountain Range

The Garnet Mountain Range lies within a triangle formed by Bonner, Ovando, and Avon, Montana (Fig. 1). Topographic characteristics are similar to those described by Scott (1978) for Chamberlain Creek in the northern portion. Generally, slopes are of gentle to moderate steepness (15 - 30%) with abrupt changes (40 - 60%) adjacent to main streams. Slopes along the northern and southern edge of the Garnets are characterized by precipitous areas of rock outcrops and talus, with elevations ranging between 1159 and 2288 m.

The cool, moist winters and hot, dry summers of the northern portion of the Garnet Mountions (Scott 1978) were typical of the area′s climate. Weather data from nearby Ovando, Potomac, and Drummond were averaged to derive temperature and precipitation patterns. Mean monthly temperatures ranged from -10.7 C in January to 17.7 C in July, with annual precipitation averaging 36.9 cm during the study period.

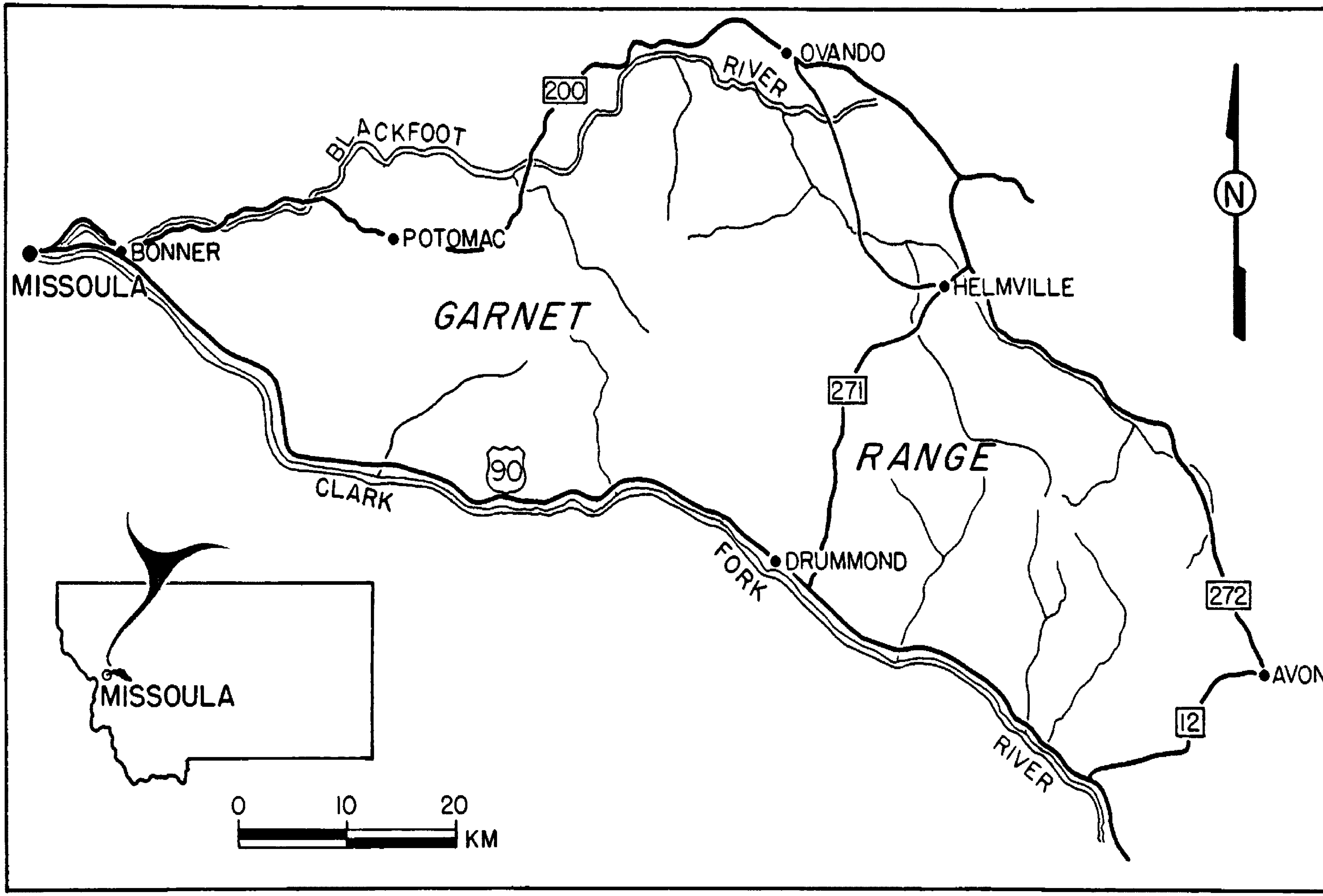

Fig. 1. The Garnet Mountain Range study area.

Forests cover a majority of the Garnet Mountain area. Major overstory dominants are lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii). In the upper drainages of Chamberlain, Pearson, and Frazier creeks, elevations above 1680 m are dominated by dense stands of lodgepole pine resulting from fires that occurred about 1900 (Ellison 1974). Elsewhere, lodgepole pine often occurs in decadent, overmature stands. Small stands of Englemann spruce (Picea engelmannii) and subalpine fir (Abies lasiocarpa) occur in moist, northerly and easterly ravines and on most forested sites above about 1980 m.

Understory cover consists largely of shrubs such as blue huckleberry (Vaccinium globulare) and grouse whortleberry (V. scoparium) on high ridges; fool's huckleberry (Menziesia ferruginea), Sitka alder (Alnus sinuata), and twinflower (Linnaea borealis) on high, cool, northerly slopes; and snowberry (Symphoricarpos albus) on lower, warm slopes. Pinegrass (Calamagrostis rubescens) understory is common at southerly, mid-elevations, and bunchgrasses, such as bluebunch wheatgrass (Agropyron spicatum) and Idaho fescue (Festuca idahoensis), predominate at lower elevations. Rock or litter understories are scattered throughout the area at all aspects and elevations.

Forest habitat types (Pfister et al. 1977) are primarily within the Pseudotsuga menziesii and Abies lasiocarpa climax series. Scree habitats are restricted to the steeper (55 - 65%), southerly or northerly slopes in the southern portion of the study area.

Fish Creek Drainage

Fish Creek is a northerly-flowing tributary of the Clark Fork River, located in the Bitterroot Mountains 50 km west of Missoula in Mineral County (Fig. 2). Including all forks, Fish Creek flows a total of approximately 74 km. The drainage is dominated by east-west running primary ridges that rise sharply from the main stream. Most slopes exceed 50%, with northerly and southerly exposures predominating. Elevations range from 976 m at the mouth of Fish Creek to 2348 m on Crater Mountain in the northwest portion of the drainage.

Climatic conditions in the Fish Creek drainage are partially influenced by Pacific maritime weather patterns (Zahn 1974). As a result, yearly temperature and precipitation averages tend to be higher than in areas to the east. At nearby Superior, mean monthly temperatures ranged from -3.4 C in January to 19.8 C in August, with annual precipitation averaging 41.0 cm during the study period.

Lyon (1973), Bohne (1974), Zahn (1974), and Lemke (1975) described vegetation on the east side of the South Fork of Fish Creek. These accounts are applicable to most of the drainage, except for the alpine habitats near the Clearwater-Clark Fork Divide.

Vegetation in the Fish Creek drainage is predominantly coniferous forest, with small areas of seral shrub fields, riparian plant communities, and alpine vegetation. Seral shrub fields and uniform stands of lodgepole pine dominate sites burned by extensive fires about 1900. Most areas that were not burned are occupied by stands of Ponderosa pine (*Pinus ponderosa*) at elevations below about 1218 m, Douglas-fir at middle elevations (1218 - 1675 m), and subalpine fir

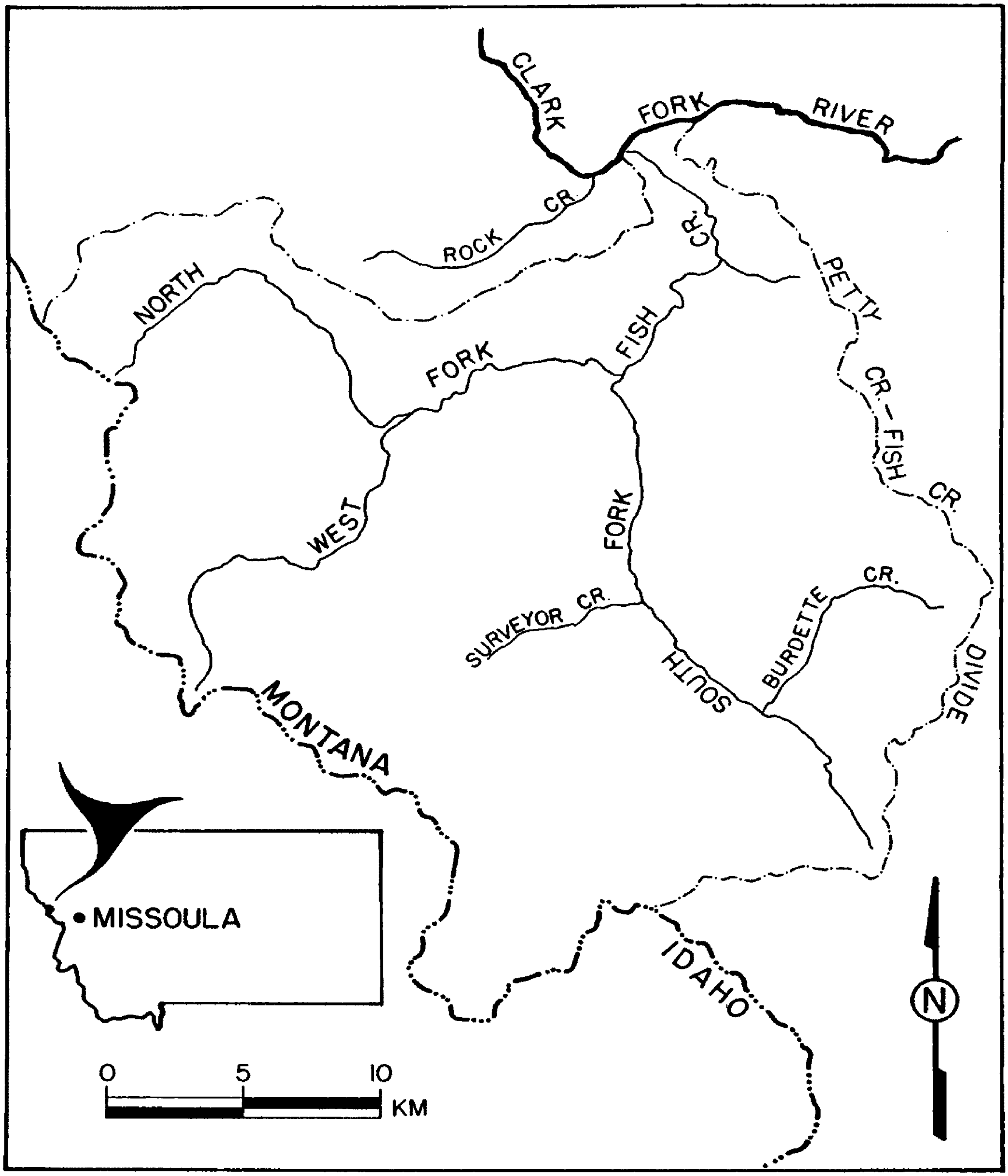

Fig. 2. The Fish Creek study area.

above 1675 m. Douglas-fir is the most common overstory species, occupying all mid-elevational aspects and most southerly aspects above 1675 m. Small narrow bands of western redcedar (Thuja plicata) occupied very cool, mesic sites along the stream bottoms of Surveyer, Thompson, and Deer creeks.

Dominant understory shrubs are fool's huckleberry on all cool, high aspects; ninebark (Physocarpus malvaceus) on slightly lower, moister sites; and snowberry on drier, westerly sites. Understories are dominated by bluebunch wheatgrass and Idaho fescue at the lower elevations.

Forest habitat types (Pfister et al 1977) in the Fish Creek drainage are dominated by the Pseudotsuga menziesii and Abies lasiocarpa climax series. Small areas in the Abies grandis climax series occur along moist ravines and on cool, moist aspects throughout the drainage. Scree habitats are common in isolated areas of steep, westerly and southerly orientation.

Thompson Falls Area

This study area consists of several drainages within about 20 km east and west of Thompson Falls (Fig. 3). Terrain is extremely steep, with many slopes exceeding 60%. Primary orientation of ridges is north-south in the Clear Creek drainage and northwest-southeast in the Thompson River area, with elevations ranging between 845 and 2135 m.

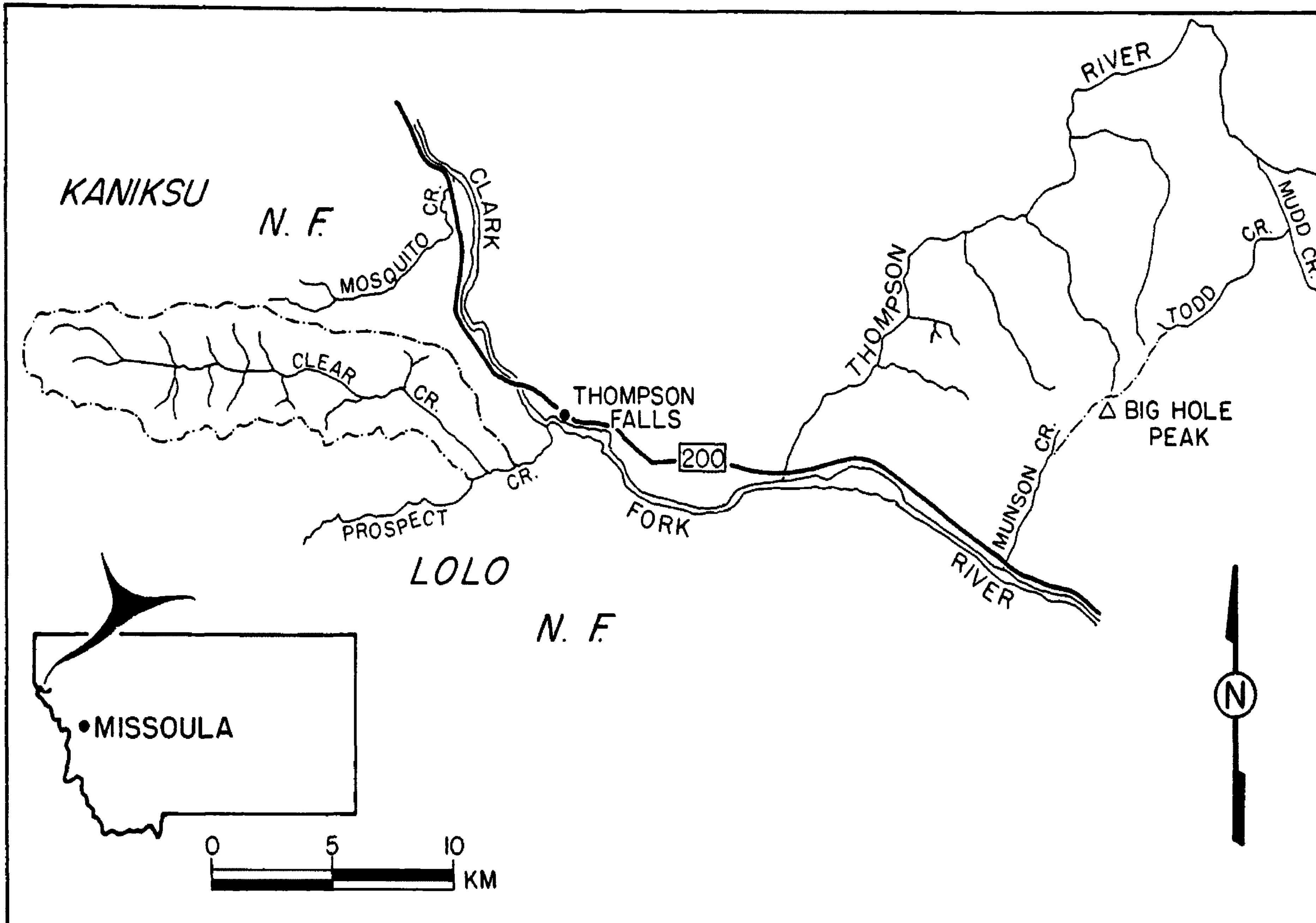

Fig. 3. The Thompson Falls study area.

Weather conditions in the area are the mildest in northwestern Montana because of the northwest-southeast alignment of the mountain ranges and a strong Pacific maritime influence (Brown 1974). The climate is characterized by warm, moist springs; long, dry summers; and wet, cool falls and winters. Average temperatures at nearby Thompson Falls ranged from -2.9 C in January to 20.5 C in August, with annual precipitation averaging 55.6 cm during the study period.

Vegetative characteristics of the area reflect the Pacific maritime influence, and have been described extensively by Brown (1974) and Tilton (1977). Forest habitat types (Pfister et al. 1977) in the *Pseudotsuga menziesii* and *Abies lasiocarpa* climax series predominate. Moist ravines and stream bottoms are dominated by the *Thuja plicata* and *Abies grandis* climax series. Scree habitats occur along the precipitous slopes adjacent to the Thompson and Clark Fork rivers.

METHODS

Bobcats were captured with a modified version of a wire-mesh live trap designed by Karpowitz and Flinders (1979). Modification consisted of a wooden rear frame and new trigger mechanism constructed with a No. 22 gate latch connected by wire to the bait rod via the latch lever. Efforts were made each year to recapture and reinstrument animals captured during the previous winter. Also, a sample of Canada lynx were instrumented to evaluate interspecific competition between the 2 species.

Primary trap locations were in areas of known bobcat and Canada lynx activity determined from tracks in the snow. Alternative trapsites were selected on the basis of dense cover near concentrations of snowshoe hare tracks or near rocky outcrops. Traps were baited with meat and a commercially prepared gland scent. Conifer boughs were used to cover the traps and line the inside bottoms. Visual attractors made of fur strips were hung near traps so as to be visible from the maximum amount of terrain. Traps were checked once every 2 to 4 days, depending on weather conditions.

Captured animals were immobilized with ketamine hydrochloride at a dosage of 22 mg/kg. Cats were then weighed, measured, eartagged with a plastic Roto-tag, assigned to a sex and approximate age class, and fitted with a lightweight radio collar. Radio collars were assembled to minimize weight (approximately 127 g). Instrumented animals were radio-relocated, weather permitting, at least once a week from the air and as often as possible from the ground.

A minimum density estimate was calculated for the Garnet Mountain study area for each winter trapping period from 1980 to 1982. Estimates were obtained by summing data from 3 sources: 1) number of bobcats trapped or shot determined from Montana Department of Fish, Wildlife, and Parks harvest registration forms, 2) number of researcher captured bobcats, and 3) number of noncaptured bobcats determined from tracks observed in the snow.

Aerial and ground radio-locations and captures were used to determine seasonal and total home range sizes and movements. All locations were plotted on U.S. Geological Survey maps divided into 0.01 km2 quadrants using the Universal Transverse Mercator (UTM) grid. Home range size estimates and movements were calculated using a computer program (Harestad 1981). This program calculated home range size by the minimum area method (Stickel 1954 and Southwood 1966) and determined movements by the straight-line distance between locations. Distances determined for consecutive locations of greater than a 14 day interval were excluded from the data base. The Chi-square distribution was used to test for possible differences in total and seasonal movement patterns. Seasons were designated as winter (December-February), spring (March-May), summer (June-August), and fall (September-November).

A sample of radio-locations at the various aspects and elevations present within the Garnet Range study area were visited during the summer and fall of 1981 and 1982. Data collected from these sites were used to infer habitat characteristics at other locations occurring at the same aspect and elevation. Accuracy of extrapolated habitat data was checked using aerial photos and habitat type maps. No radio-locations were visited in either the Fish Creek or Thompson Falls study areas because of time restrictions. Habitat descriptions for locations in those areas were obtained solely from aerial photos, topographic maps, and habitat type maps.

Habitat characteristics on visited location sites were appraised by sampling 375-m2 plots (Pfister et al. 1977). Site characteristics recorded were vegetative cover type; forest habitat type; slope; aspect; elevation; horizontal configuration and position on slope; cover density; and percent plot coverage of rocks/talus, forest debris, tree canopy, shrubs, and herbaceous vegetation. Vegetative cover types were designated according to the dominant overstory and understory vegetative features. For the Garnet Mountain study area, 6 vegetative cover types were designated as follows: 1) timbered overstory with a dominant understory of shrub species, 2) timbered overstory with a dominant understory consisting of a combination of forbs and grasses, 3) timbered overstory with a predominantly forest debris understory, 4) timbered overstory with a predominantly bare ground understory, 5) rock understory with scattered timbered coverage ($\leq$ 5% canopy closure), and 6) rock understory with a timbered overstory (> 5% canopy closure). Forest habitat types were assigned according to the system developed for Montana by Pfister et al. (1977). For ease in summarizing data, habitat types of radio-relocations were grouped by disregarding phases to form major habitat types for each area. Percent plot coverage values were estimated using the method described by Daubenmire (1959).

Habitat use was evaluated using the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975) and based on the total percentage of radio-locations observed in each recorded habitat characteristic. The SPSS subprograms "FREQUENCIES" and "T-Test" were used to calculate these percentages and test for possible differences in mean seasonal elevations. Availability of a given habitat factor and possible significant differences in availability and bobcat use were also determined (Marcum and Loftsgaarden 1980). Statistically significant differences were indicated as follows; + or - when bobcat use is significantly greater or less than availability for $p < 0.05$ and ++ or -- for $p < 0.01$. Lack of a sign indicates no significant difference.

RESULTS

Trapping and Population Estimates

Nineteen study animals, 14 bobcats and 5 lynx, were captured during winters 1980 to 1982 (Table 1). Three of these were trapped by professional trappers, 3 were treed by hounds, and the rest were captured by the researcher and project assistants. A total of 488 radio-locations were obtained during tracking periods that ranged from 2 weeks to 30 months. Six transmitters failed, 7 animals were trapped or shot, and 2 died of presumably natural causes. Data are still being collected from bobcats M(male)109 and F(female)3 and from Canada lynx M103 and F110.

Minimum number of bobcats known to occupy the Garnets varied from a low of 10 (1/176.8 km) in 1981 to a high of 21 (1/84.2 km) in 1982 (Table 2). The low estimate in 1981 occurred during a year of low snow accumulation when only the highest elevations were continuously snow-covered. Thus, some cats were certainly missed in 1981, and some were probably missed in the other years as well; the figures provide a minimum estimate.

Home Range and Movements

Areas used by each instrumented bobcat are shown in Figures 4 through 6. Information collected from 266 radio-locations on 8 resident adult bobcats, 6 females and 2 males (Table 3), provided sufficient data to estimate home range sizes. Home range estimates for females ranged from 50.1 to 147.8 km2 and for the males 55.0 and 70.9 km2. The mean

Table 1. Physical characteristics, study area, number of locations, and fate of bobcats and Canada lynx captured during study.

Cat Number[1, 2]	Date Captured	Study Area[3]	Age[4]	Wt. (kg)	Number Locations	Last Contact	Fate[5]
Bobcat							
F101	31 Mar 80	G	J	5.0	36	2 Feb 81	TF
F51	31 Mar 80	F	J	4.1	61	13 Aug 82	TF
M102	18 Dec 80	G	A	12.2	40	10 Nov 81	Shot
F1	27 Jan 81	T	A	7.7	28	10 Nov 82	TF
F105	26 Dec 81	T	A	8.4	10	9 Oct 82	TF
M2	28 Dec 81	F	A	9.1	4	26 Jul 82	TF
F3	29 Jan 82	T	J	4.1	10	6 Apr 83	S
F106	19 Feb 82	G	J	3.6	7	26 Apr 82	D
F107	26 Feb 82	G	J	4.1	14	23 Nov 82	T
F108	17 Mar 82	G	A	7.0	45	7 Dec 82	T
M4	18 Mar 82	F	A	Unknown	9	8 Dec 82	D
M109	26 Mar 82	G	A	10.9	19	29 Mar 83	S
F111	31 Mar 82	G	A	6.4	21	23 Nov 83	TF
F52	8 Apr 82	G	A	6.4	29	7 Dec 82	T
Lynx							
M103	12 Jan 81	G	A	10.4	57	23 Nov 82	S
M104	22 Jan 81	G	A	8.6	34	12 Dec 81	T
F110	1 Apr 82	G	A	8.2	32	7 Dec 82	S
F112	6 Apr 82	G	A	6.8	29	7 Dec 82	T
M113	1 Dec 82	G	A	7.7	3	18 Dec 82	Shot

[1]F = female, M = male.

[2]N = eartag number.

[3]G = Garnet Mountain Range, F = Fish Creek, T = Thompson Falls.

[4]J = juvenile, A = adult.

[5]TF = transmitter failure, T = trapped, D = dead of natural causes, S = survived and transmitter functional.

Table 2. Minimum estimates of the number of bobcats known to have occupied all or part of the Garnet Mountain study area during winter periods, 1980-1982. Estimates are based on trapper harvest, researcher captures, and tracks in snow.

Year	Trapper Harvest	Researcher Captures	Tracks	Total	Density (km)
1980	12	1	4	17	1/104.0
1981	3	1	6	10	1/177.8
1982	13	6	2	21	1/84.2

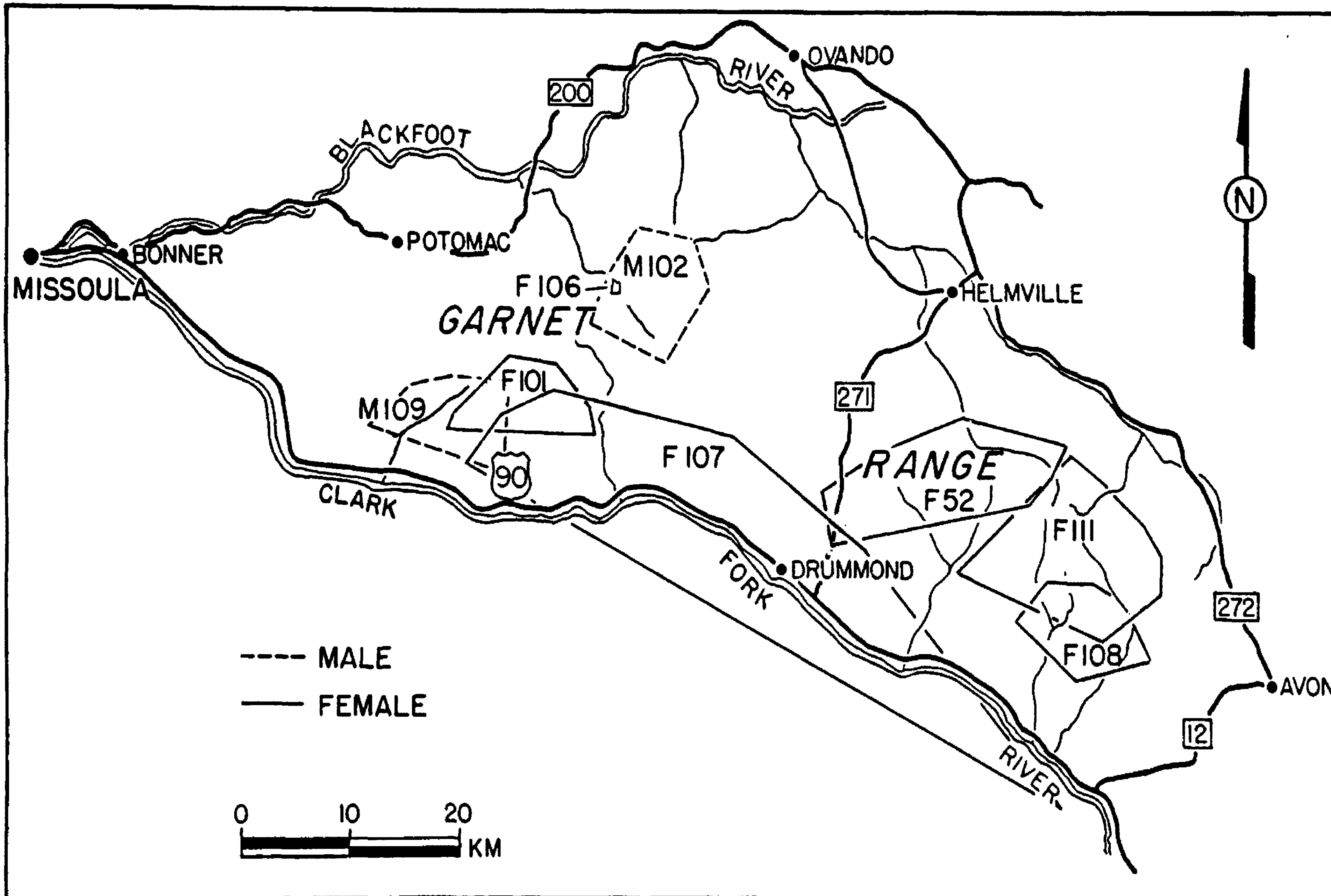

Fig. 4. Home ranges of instrumented bobcats between March 1980 and December 1982 in the Garnet Mountain study area. Home range depicted for F107 is that of a dispersing individual.

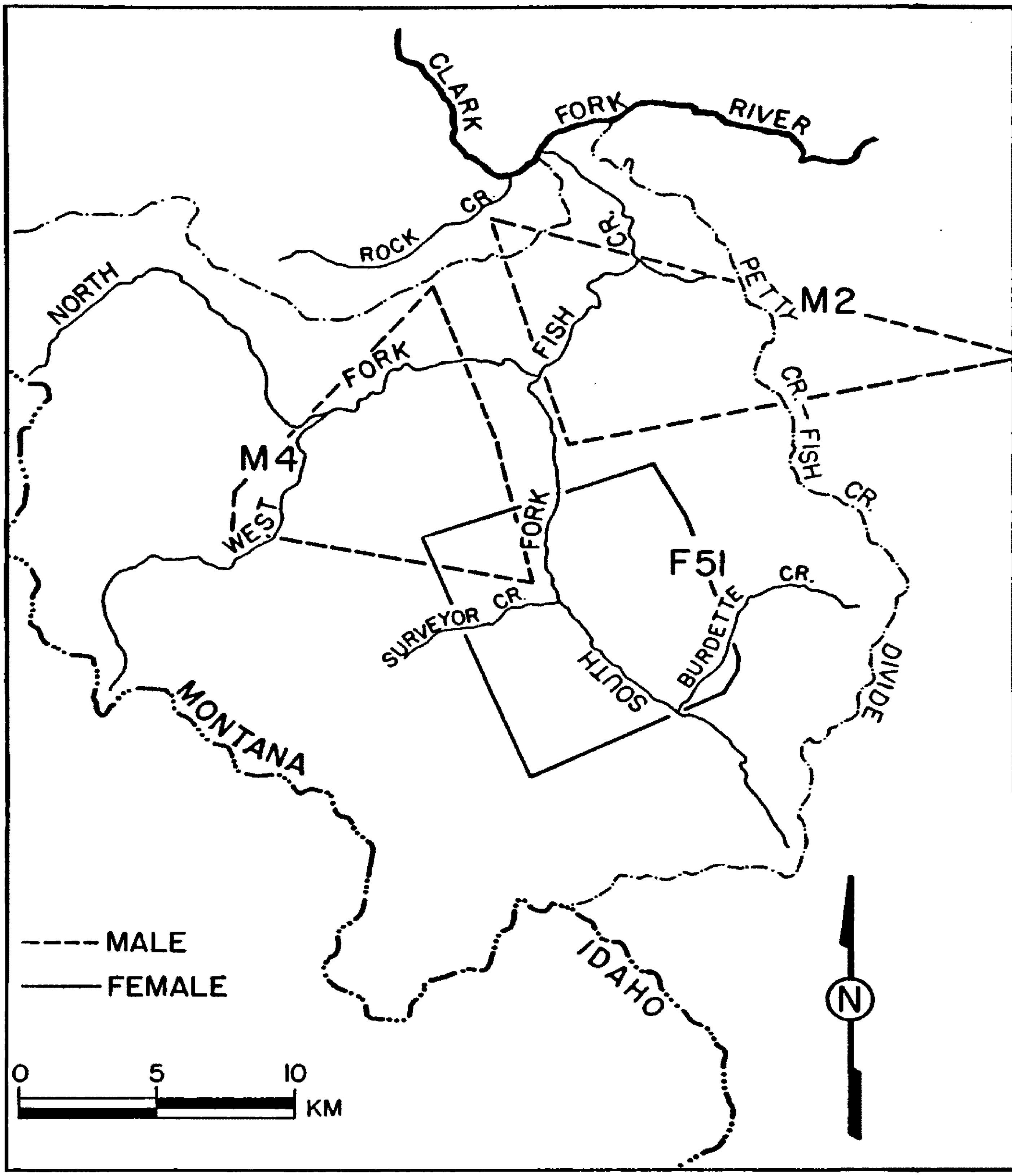

Fig. 5. Home range of F51 from March 1980 to August 1982 and the areas used by M2 and M4 during 1982 in the Fish Creek drainage.

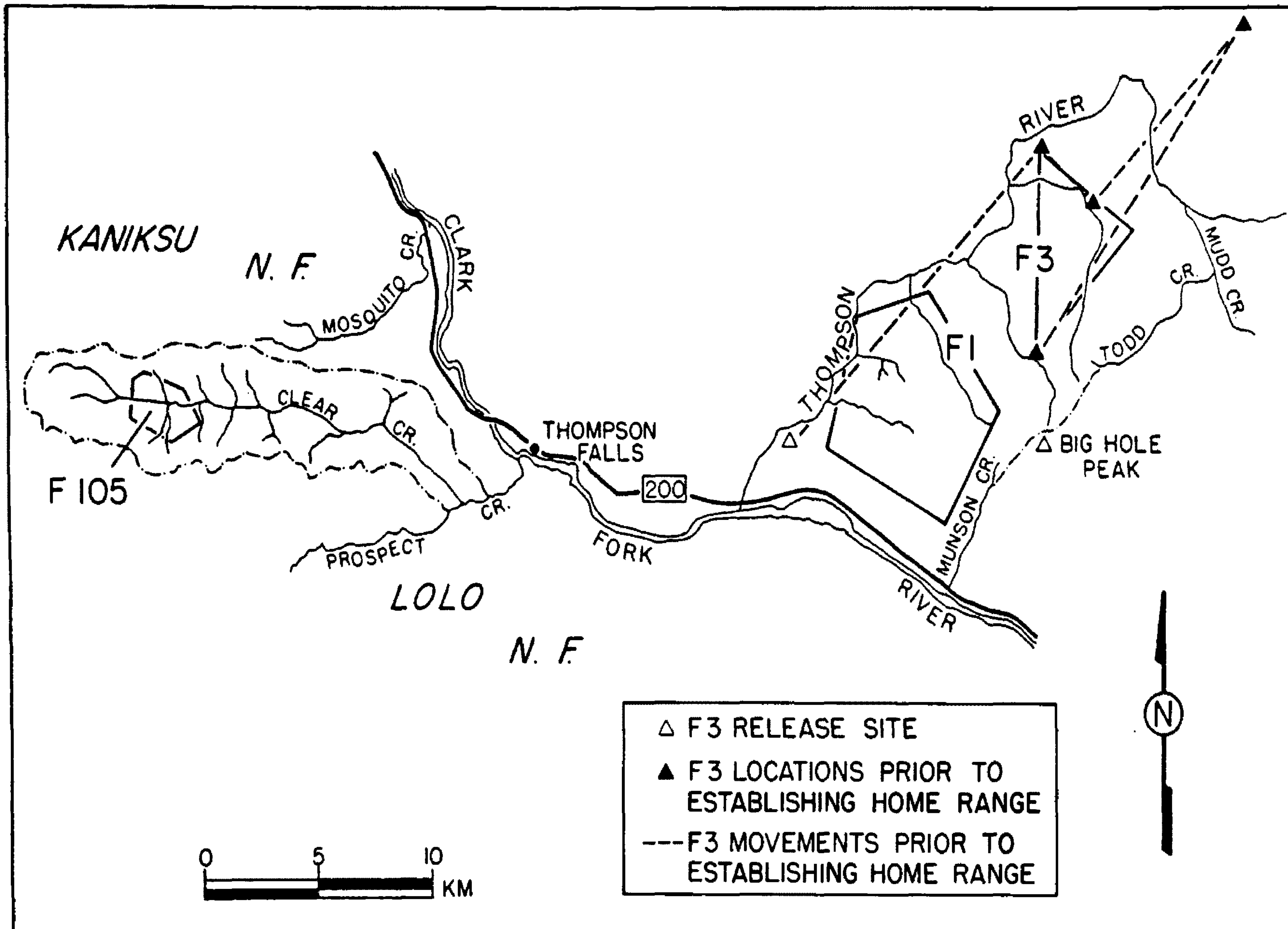

Fig. 6. Home ranges of instrumented bobcats between January 1981 and April 1983 in the Thompson Falls study area and the movements of F3 prior to establishing home range. Range of F105 is considered area of use because of insufficient data to accurately estimate home range.

Table 3. Individual home range sizes of instrumented bobcats. (N) = number of radio-locations used to estimate the home range size.

Bobcat Number	Year	Winter	Spring	Summer	Fall	Total
F101	1980	--	35.6 (8)[1]	27.5 (14)	32.1 (19)	
	1981	11.4 (5)	TD[2]	--	--	53.3 (28)[3]
F51	1980	--	NC[2] (3)	6.6 (5)	NC[2] (3)	
	1981	27.6 (5)	39.9 (10)	16.0 (11)	20.0 (7)	
	1982	NC[2] (1)	NC[2] (4)	7.6 (12)	TD[2]	91.4 (61)
F1	1981	NC[2] (2)	2.6 (6)	21.9 (9)	16.8 (5)	
	1982	NC[2] (1)	NC[2] (2)	NL[2]	NC[2] (3)	50.1 (28)
F105	1981	NC[2] (4)	NC[2] (4)	NL[2]	NC[2] (2)	6.6 (10)[4]
F3	1982	NC[2] (1)	NC[2] (1)	NL[2]	NC[2] (3)	
	1983	NC[2] (3)	NC[2] (2)	--	--	20.5 (8)[3,4]
F106	1982	NC[2] (3)	NC[2] (4)	AD[2]	--	0.4 (7)[4]
F107	1982	NC[2] (1)	104.6 (4)[1,4]	107.4 (6)[4]	NC[2] (3)	478.8 (9)[3,4]
F108	1982	--	22.9 (10)	29.4 (25)	21.3 (8)	59.5 (45)
F111	1982	--	35.3 (5)	45.9 (9)	74.2 (7)	147.8 (21)
F52	1982	--	56.7 (7)	14.8 (12)	37.5 (8)	127.2 (27)
Female Mean		19.5 (10)	31.5 (38)	21.2 (97)	33.6 (44)	88.2 (210)
M102	1981	22.7 (13)	43.2 (11)	6.3 (7)	26.2 (8)	70.9 (39)
M2	1981	NC[2] (1)	NC[2] (2)	NC[2] (1)	TD[2]	90.6 (4)[4]
M4	1982	--	NC[2] (4)	NC[2] (1)	NC[2] (4)	70.0 (9)[4]
M109	1982	--	NC[2] (2)	15.9 (9)	14.5 (6)	55.0 (17)
Male Mean		--	--	11.1 (16)	20.4 (14)	63.0 (56)
Overall Mean		20.6 (23)	33.4 (49)	19.2 (113)	31.1 (66)	81.9 (266)

[1]Juvenile during that season.

[2]NC = not calculated because of insufficient data, NL = not located, TD = transmitter dead, AD = animal dead.

[3]Home range estimate based only on radio-locations obtained as an adult.

[4]Represents size of area used and not a home range estimate.

home range size for females (88.2 km2) was almost 1.5 times larger than that for males (63.0 km2). Seasonally, similar home range variation occurred among the sexes.

Female home ranges were smallest in winter and summer (11.4 to 45.9 km2) and largest in spring and fall (2.6 to 74.2 km2). One of the smallest female home ranges observed (14.8 km2) was for F52 who was known to be rearing kittens during the summer. Males in contrast, had the smallest home ranges in summer and fall (6.3 to 26.2 km2) and the largest in winter (22.7 km2) and spring (43.2 km2). The spring range of M102 was the largest observed for a male and occurred during the breeding season. In general, the overall mean (Table 3) suggests that bobcat seasonal home ranges are smallest in winter (20.6 km2) and summer (19.2 km2) and largest in spring (33.4 km2) and fall (31.1 km2). Data collected from F105, M2, and M4 were not sufficient to obtain accurate estimates of home range sizes.

The distribution of distances (Table 4) between consecutive radio-locations of 14 days or less were not statistically different between males and females ($X2 = 4.65$, $df = 4$, $P > 0.05$). However, females seemed slightly more likely than males to be found < 1 km (16.8%) and > 9 km (10.5%) from their previous locations. Males, on the other hand, were located at these distances only 11.6% and 0.0% of the time. During summer, females were also more likely to be located < 1 km from their previous location (26.4%) than during all other seasons combined. Movements for females during this period averaged 3.2 km, the lowest observed. An exceptionally long movement of 64.4 km in 47 days by M102 was excluded from this analysis. This individual was reportedly

Table 4. Distribution of distances between consecutive radio-locations of 14 days or less and average distance traveled by adult bobcats by sex and season.

	Number of Locations						
	0-1 (km)	1-3 (km)	3-6 (km)	6-9 (km)	> 9 (km)	Total	Average (km)
Males							
Winter	1	6	4	1	0	12	3.2
Spring	1	2	3	3	0	9	4.7
Summer	1	3	6	2	0	12	3.8
Fall	2	2	4	2	0	10	4.0
Total	5	13	17	8	0	43	3.9
Females							
Winter	0	0	2	1	0	3	5.7
Spring	3	10	11	3	4	31	4.2
Summer	18	24	20	7	4	73	3.2
Fall	3	5	16	5	7	36	5.3
Total	24	39	49	16	15	143	4.0
Grand Total	29	52	66	24	15	186	

shot on the Flathead Indian Reservation on 12 December 1982.

Home range sizes and movements of juveniles and dispersing individuals varied considerably. Four female bobcats (F101, F106, F107, and F3) were captured as juveniles and followed through the winter and spring of 1982. Home range sizes for these individuals, except for F3, varied from 0.4 to 104.6 km2 (Table 3). Insufficient locations were obtained to estimate F3's juvenile home range.

F106, captured on 19 February 1982, had the smallest home range, being rarely located far from the seclusion of an extensive rock outcropping along Elk Creek (Fig. 4). The longest movement observed was 1.1 km. She was in poor condition when trapped and was subsequently found dead on 18 May 1982, presumably from natural causes. In contrast, F107 had the largest home ranges observed during this study (Table 3). Only 14 locations were obtained in 11 months before she was trapped in January of 1983. Total area used was 478.8 km2, with seasonal ranges varying from 104.6 to 107.6 km2. The longest movement observed was 59.0 km in 83 days, with 16.0 km as the average. This extensive mobility often contributed to my inability to locate her for periods as long as 2 months. Therefore, the movements of F107 should be considered as minimum.

Juvenile F3 was captured on 29 January 1982 in the Thompson Falls dump, 24 km west of the city and released along the lower Thompson River. Ten locations were obtained from 30 January 1982 to 6 April 1983. Her movements as a juvenile and dispersing adult averaged 13.3 km, were highly erratic, and covered an area of 93.6 km2 (Fig. 6). At times, she moved through the established home range of adult female F1, but did not remain there. She apparently established a home range of 20.5 km2 on 8 December 1982, to the north of F1's.

Habitat Use

A total of 233 accurately fixed radio-locations provided information on seasonal and annual habitat use. Winter was generally characterized by greater than expected use of elevations below 1650 m on all study areas (Table 5). Mean elevations during this period were significantly lower than those during the rest of the year, except at Fish Creek (Fig. 7). Also during winter, bobcat use typically exceeded that expected for aspects that were, at least in the Garnets, west and southerly (Table 6), for lower slopes and stream bottoms (Table 7), and for lower slope inclines (Table 8). During the rest of year, bobcat use was greater than expected for elevations above 1650 m and for more upper slope positions. Also during this period, use of aspects and slope inclines were generally in proportion to their availability with the following exceptions: 1) northwest aspects and level areas were avoided during all seasons and 2) slope inclines > 75% were used most during the summer denning period.

In the Garnets, the low elevation *Pseudotsuga menziesii*/*Symphoricarpos albus* habitat type was the dominant type used during winter, with the mid- to high-elevation *Pseudotsuga menziesii*/*Calamagrostis rubescens* habitat type dominating during spring through fall (Table 9). The spring-fall period also included the greatest use of the *Abies lasiocarpa* climax series. *Pseudotsuga menziesii*/*Linnaea borealis* and *Abies lasiocarpa*/*Linnaea borealis* were

Table 5. Percentages of availability and bobcat use related to elevation by study area.

Elevation feet (meters)	% Availability	% Bobcat Use Winter	Spring	Summer	Fall	Total
GMR[1]		N = 14	N = 33	N = 54	N = 33	N = 134
<4500 (<1370)	2.4	28.6	- 0.0	-- 0.0	3.0	3.7
4600-5300 (1400-1620)	27.1	35.7	15.2	--11.1	15.2	-15.7
5400-6100 (1650-1860)	44.8	35.7	48.5	48.4	48.5	47.0
>6100 (>1860)	25.8	-- 0.0	36.4	40.7	33.3	33.5
Fish Creek		N = 6	N = 18	N = 26	N = 8	N = 58
<4500 (<1370)	46.7	83.3	38.8	30.7	62.5	43.1
4600-5300 (1400-1620)	39.3	16.7	50.0	61.6	37.5	50.0
5400-6100 (1650-1860)	12.0	- 0.0	5.6	7.0	- 0.0	5.2
>6100 (>1860)	2.0	0.0	5.6	0.0	0.0	1.7
TF[1]		N = 10	N = 11	N = 7	N = 13	N = 41
<4500 (<1370)	53.3	80.0	36.4	42.9	23.1	43.9
4600-5300 (1400-1620)	22.7	10.0	36.4	14.3	30.8	24.4
5400-6100 (1650-1860)	18.0	10.0	27.2	42.8	38.5	29.3
>6100 (>1860)	6.0	- 0.0	- 0.0	0.0	7.6	2.4

[1]GMR = Garnet Mountain Range, TF = Thompson Falls.

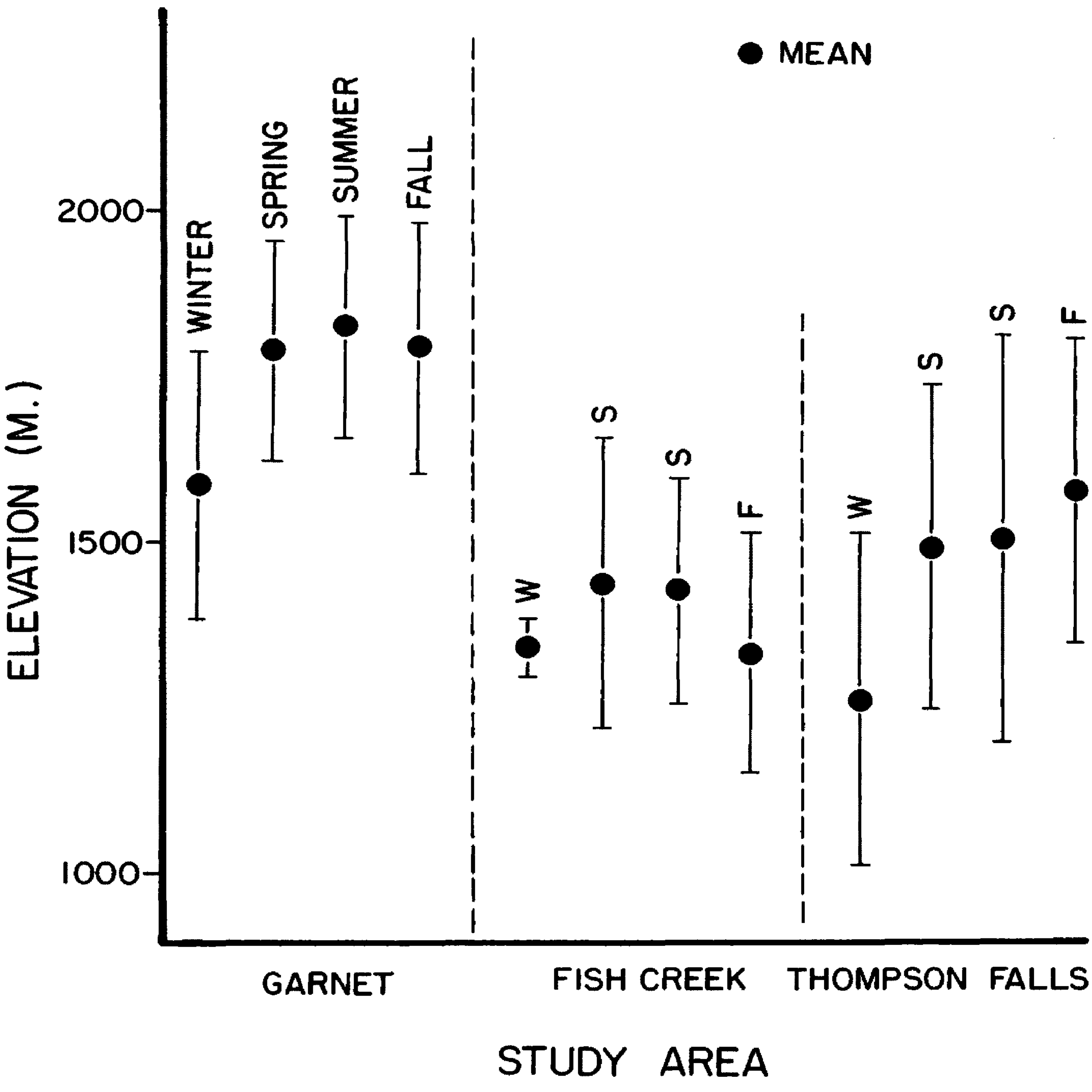

Fig. 7. Mean and standard deviation of seasonal elevations of bobcat radio-locations by study area.

Table 6. Percentages of availability and bobcat use related to aspect by study area.

Aspect	% Availability	% Bobcat Use Winter	Spring	Summer	Fall	Total
GMR[1]		N = 14	N = 33	N = 54	N = 33	N = 134
N	11.0	21.4	9.1	14.8	12.1	13.4
NE	12.4	-- 0.0	18.2	14.8	6.1	11.2
E	10.0	- 0.0	9.1	13.0	27.3	14.9
SE	11.0	14.3	9.1	9.3	6.1	9.0
S	7.1	14.3	9.1	16.7	12.1	13.4
SW	13.8	28.6	15.2	16.7	18.2	17.9
W	11.4	21.4	15.2	7.4	15.2	12.7
NW	20.0	-- 0.0	15.2	- 7.4	-- 3.0	-- 7.5
Level	3.3	0.0	-- 0.0	-- 0.0	-- 0.0	-- 0.0
Fish Creek		N = 6	N = 18	N = 26	N = 8	N = 58
N	12.0	33.3	5.6	30.8	12.5	20.7
NE	16.7	-- 0.0	11.1	19.2	-- 0.0	12.1
E	9.3	33.3	22.2	23.1	12.5	22.4
SE	14.0	16.7	11.1	-- 0.0	12.5	6.9
S	9.3	- 0.0	5.6	11.5	12.5	8.6
SW	11.3	- 0.0	22.2	3.8	12.5	10.3
W	7.3	16.7	22.2	11.5	37.5	19.0
NW	16.7	-- 0.0	-- 0.0	-- 0.0	-- 0.0	-- 0.0
Level	3.4	0.0	0.0	- 0.0	0.0	- 0.0
TF[1]		N = 10	N = 11	N = 7	N = 13	N = 31
N	10.7	10.0	- 0.0	28.6	46.2	22.0
NE	27.3	30.0	27.3	14.2	7.7	19.5
E	6.7	- 0.0	- 0.0	- 0.0	15.2	4.9
SE	8.7	10.0	- 0.0	- 0.0	- 0.0	2.4
S	4.0	0.0	18.1	0.0	0.0	4.9
SW	11.3	10.0	27.3	28.6	- 0.0	14.6
W	9.3	30.0	18.2	28.6	7.1	19.5
NW	20.0	10.0	9.1	-- 0.0	23.1	12.2
Level	2.0	0.0	0.0	0.0	0.0	0.0

[1]GMR = Garnet Mountain Range, TF = Thompson Falls.

Table 7. Percentages of availability and bobcat use related to slope by study area.

% Slope	% Availability	% Bobcat Use Winter	Spring	Summer	Fall	Total
GMR[1]		N = 14	N = 33	N = 54	N = 33	N = 134
0-25	28.1	++75.0	39.4	44.4	33.3	++44.1
26-50	49.5	25.0	48.5	35.2	48.5	40.4
51-75	20.5	-- 0.0	9.1	16.7	15.2	12.5
> 75	1.9	0.0	3.0	3.7	3.0	2.9
Fish Creek		N = 6	N = 18	N = 26	N = 8	N = 58
0-25	14.7	-- 0.0	5.6	·15.4	25.0	12.0
26-50	28.0	66.7	27.8	30.8	37.5	34.5
51-75	44.7	33.3	55.6	50.0	37.5	48.3
> 75	12.6	- 0.0	11.0	3.8	- 0.0	5.2
TF[1]		N = 10	N = 11	N = 7	N = 13	N = 41
0-25	16.0	10.0	27.3	-- 0.0	7.7	12.2
26-50	38.0	60.0	45.4	-- 0.0	53.8	43.9
51-75	26.0	30.0	9.1	+71.4	30.8	31.7
> 75	20.0	-- 0.0	18.2	28.6	7.7	12.2

[1]GMR = Garnet Mountain Range, TF = Thompson Falls.

Table 8. Percentages of availability and bobcat use related to slope position by study area.

Slope Position	% Avail-ability	% Bobcat Use Winter	Spring	Summer	Fall	Total
GMR[1]		N = 14	N = 33	N = 54	N = 33	N = 134
Ridge top	11.0	-- 0.0	6.1	13.0	3.0	7.5
Upper slope	28.1	14.3	39.4	33.3	48.5	36.6
Mid-slope	29.0	14.3	18.2	14.8	15.2	-15.7
Lower slope	27.1	42.9	36.4	37.0	33.3	36.6
Stream bottom	4.8	28.6	-- 0.0	1.9	-- 0.0	3.7
Fish Creek		N = 6	N = 18	N = 26	N = 8	N = 58
Ridge top	6.0	33.3	22.2	19.2	12.5	+20.7
Upper slope	28.7	33.3	33.3	38.5	12.5	32.8
Mid-slope	30.7	16.7	16.7	-- 7.7	12.5	--12.1
Lower slope	28.0	16.7	27.8	30.8	50.1	31.0
Stream bottom	6.6	- 0.0	- 0.0	3.8	12.5	3.4
TF[1]		N = 10	N = 11	N = 7	N = 13	N = 41
Ridge top	9.3	- 0.0	18.1	- 0.0	15.4	9.8
Upper slope	29.3	10.0	27.3	42.8	61.5	36.6
Mid-slope	33.3	40.0	27.3	28.6	-- 0.0	22.0
Lower slope	23.3	50.0	27.3	28.6	23.1	31.6
Stream bottom	4.8	0.0	0.0	0.0	0.0	-- 0.0

[1]GMR = Garnet Mountain Range, TF = Thompson Falls.

Table 9. Percentage of accurately fixed bobcat radio-locations for the major habitat types (Pfister et al. 1977) by study area.

Habitat Type	Percentage of Locations				
	Winter	Spring	Summer	Fall	Annual
Garnet Mountains	N = 14	N = 32	N = 53	N = 33	N = 132
Scree	0.0	3.1	18.9	6.1	9.8
Pseudotsuga menziesii/Linnaea borealis	7.1	6.2	5.7	6.1	6.1
Pseudotsuga menziesii/Symphoricarpos albus	42.8	9.4	7.5	21.2	15.2
Pseudotsuga menziesii/Calamagrostis rubescens	0.0	43.8	24.5	21.2	25.8
Abies lasiocarpa/Linnaea borealis	0.0	9.4	5.7	9.1	6.8
Abies lasiocarpa/Xerophyllum tenax	14.3	12.5	1.9	18.2	9.8
Fish Creek	N = 6	N = 18	N = 26	N = 8	N = 58
Pseudotsuga menziesii/Physocarpus malvaceus	50.0	33.3	40.0	37.5	37.9
Pseudotsuga menziesii/Vaccinium globulare	0.0	5.6	15.4	0.0	8.6
Pseudotsuga menziesii/Calamagrostis rubescens	16.7	16.7	0.0	12.5	8.6
Abies grandis/Xerophyllum tenax	16.7	0.0	15.4	0.0	8.6
Abies lasiocarpa/Xerophyllum tenax	0.0	11.1	11.5	12.5	10.3
Thompson Falls	N = 10	N = 11	N = 7	N = 13	N = 41
Scree	10.0	9.1	42.8	0.0	12.2
Pseudotsuga menziesii/Physocarpus malvaceus	30.0	9.1	0.0	7.7	12.2
Thuja plicata/Clintonia uniflora	40.0	18.2	0.0	7.7	17.1
Abies lasiocarpa/Menziesia ferruginea	0.0	9.1	14.3	30.8	14.6
Abies lasiocarpa/Xerophyllum tenax	20.0	27.3	0.0	15.4	17.1

used at consistently low levels throughout the year, whereas scree use increased from zero in winter to a peak of 19% in summer.

At Fish Creek, use of the low to mid-elevation Pseudotsuga menziesii/Physocarpus malvaceus habitat type dominated throughout the year (Table 9). During spring through fall, low level use occurred for the 3 mid- to high-elevation types of Pseudotsuga menziesii/Calamagrostis rubescens, Pseudotsuga menziesii/Vaccinium globulare, and Abies lasiocarpa/Xerophyllum tenax. No use of scree habitats was observed.

Winter use around Thompson Falls was dominated by the low to mid-elevation Thuja plicata/Clintonia uniflora and Pseudotsuga menziesii/Physocarpus malvaceus habitat types (Table 9). Abies lasiocarpa/Menziesia ferruginea and Abies lasiocarpa/Xerophyllum tenax habitat types generally dominated from spring through fall. Bobcats sought steep, rocky habitats during summer as evidenced by an increase in the use of scree.

On an annual basis, the cover types of timbered shrub, timbered forb/grass, and rock with tree canopy closure > 5% accounted for 76% of the radio-locations (Fig. 8). Timbered shrub and timbered forb/grass were used in all seasons, and rock with > 5% tree canopy closure in all except winter. Timbered shrub was the most heavily used (36%) of these 3, followed by timbered forb/grass (26%), and rock with > 5% canopy closure (14%). Timbered forest debris and timbered bare ground accounted for a total of 20% of the locations, with the least used, rock with $\leq$ 5% tree canopy closure, accounting for 2%. Three apparent trends in seasonal cover type use were evident: 1) timbered shrub and timbered

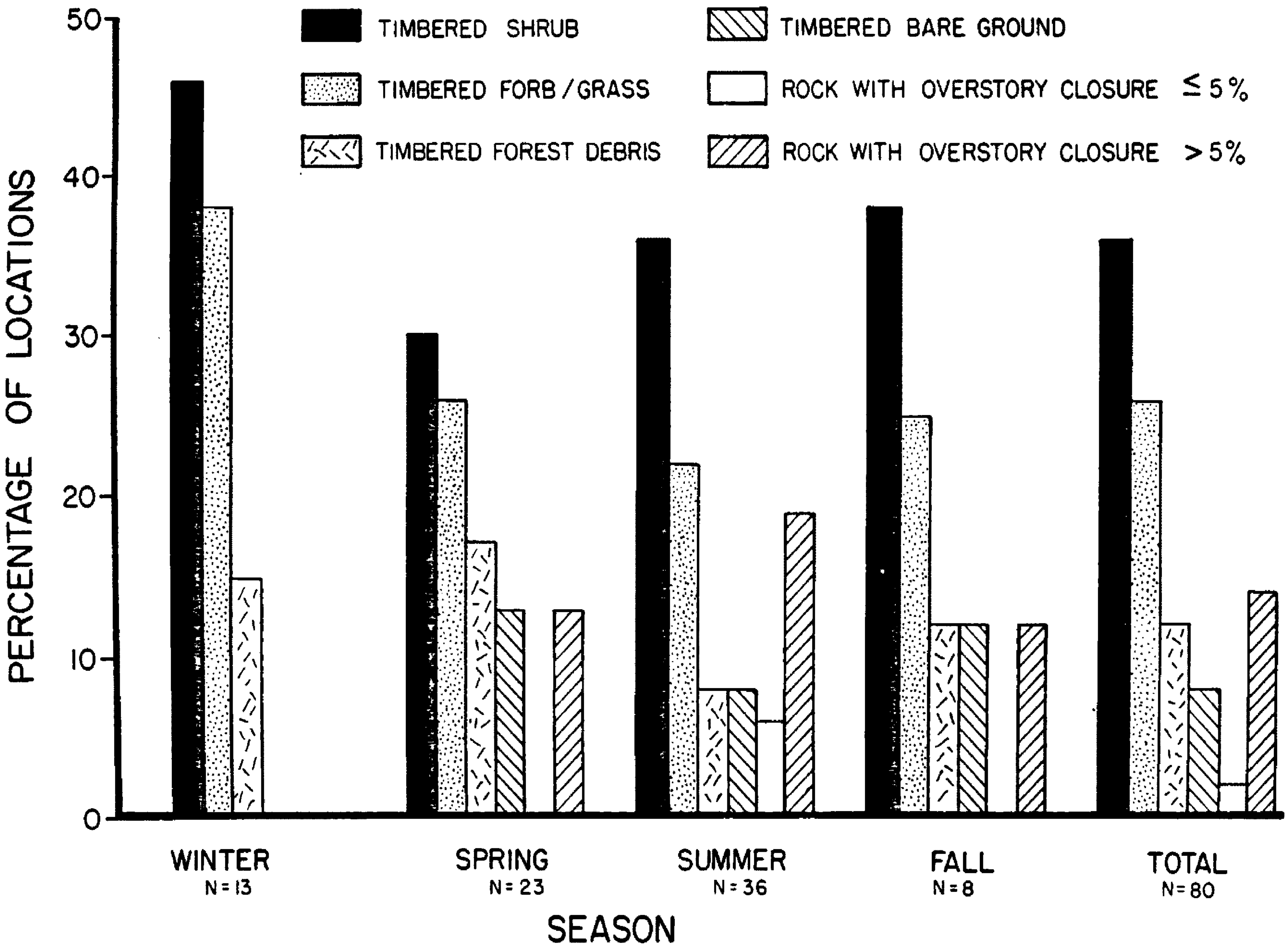

Fig. 8. Percentages of accurately fixed bobcat radio-locations for the 6 cover types in the Garnet Mountain study area. Only visited locations were included in the analysis.

forb/grass were used consistently more during all seasons than any other cover type; 2) bobcats used only 3 cover types (timbered shrub, timbered forb/grass, and timbered forest debris) during winter, all of which had at least a partial understory layer above existing snow levels; and 3) the upsurge in the use of the rock with > 5% canopy closure cover type and in percentage of locations consisting of talus or geomorphic rock formations (Table 10) in summer are suggestive of the seasonal importance of a rock habitat feature.

Bobcats were consistently located most frequently in stands with a extensive overstory canopy (Table 11). Canopy coverage classes 50-75% and 75-95% accounted for 67.4% of the locations in the Garnet Mountains, 87.9% at Fish Creek, and 87.2% at Thompson Falls. Bobcats were rarely located in stands with 1-5% canopy coverage. Stands with canopy coverage in the 5-25% and 25-50% coverage classes received only minor use throughout the year.

Forest roads and logged areas appeared to influence bobcat habitat use (Tables 12 and 13). Overall average distance to the nearest road ranged from 389 m in the Garnets to 961 m near Thompson Falls. Seasonally, average distances were smallest in winter and largest in summer. Logged areas received only 12% of the total bobcat use. Such areas appeared to have been managed under a selection cutting prescription. Areas managed under a clear cut prescription were not used by bobcats.

Table 10. Percentage of accurately fixed bobcat radio-locations visited in the Garnet Mountains with a rock understory and the average percentage of rock understory coverage.

Season	Number of Visited Locations	Percentage of Locations with a Rock Understory	Average Percentage of Rock Coverage of Location
Winter	13	30.8	26.3
Spring	23	17.4	38.1
Summer	36	44.4	50.2
Fall	8	12.5	62.5
Annual	80	32.5	43.2

Table 11. Percentage of accurately fixed bobcat radio-locations related to overstory canopy coverage by study area. (Garnet Mountain percentages were derived from ground truth data and aerial photo estimates. Fish Creek and Thompson Falls percentages were obtained solely from aerial photo estimates.)

	Percentage of Locations				
Coverage Class (%)[1]	Winter	Spring	Summer	Fall	Annual
Garnet Mountains	N = 14	N = 31	N = 54	N = 30	N = 129
1-5	14.3	0.0	3.7	0.0	3.1
5-25	28.6	9.7	9.3	3.3	10.1
25-50	21.4	16.1	22.2	6.7	17.0
50-75	28.6	25.8	24.1	23.3	24.8
75-95	7.1	45.2	38.9	63.3	42.6
95-100	0.0	3.2	1.9	3.3	2.3
Fish Creek	N = 6	N = 18	N = 26	N = 8	N = 58
1-5	0.0	0.0	0.0	0.0	0.0
5-25	33.3	5.6	11.5	0.0	10.3
25-50	0.0	0.0	3.8	0.0	1.7
50-75	33.3	33.3	15.4	25.0	24.1
75-95	33.3	61.1	69.2	75.0	63.8
95-100	0.0	0.0	0.0	0.0	0.0
Thompson Falls	N = 9	N = 11	N = 7	N = 12	N = 39
1-5	0.0	0.0	0.0	0.0	0.0
5-25	0.0	0.0	28.6	0.0	5.1
25-50	11.1	9.1	14.3	0.0	7.7
50-75	11.1	45.5	28.6	8.3	23.1
75-95	77.8	45.5	28.6	91.7	64.1
95-100	0.0	0.0	0.0	0.0	0.0

[1] Daubenmire 1959.

Table 12. Average distance to the nearest forest road in meters.

Study Area	Winter	Spring	Summer	Fall	Overall
Garnet Mountain Range	166	357	540	494	389
Fish Creek	426	514	385	735	515
Thompson Falls	404	890	1325	1226	961

Table 13. Percentage of accurately fixed bobcat radio-locations related to logged areas within the Garnet Mountain study area.

	Percentage of Locations				
Location Type	Winter	Spring	Summer	Fall	Overall
Logged	30.8	8.3	11.1	0.0	12.0
Non-logged	69.2	91.7	88.9	100.0	88.0

Den Locations

During intensive summer ground tracking periods in 1982, dens of F108 and F52 were found in steep, inaccessible areas in the Garnet Mountains. The dominant feature at both dens was the presence of extensive rock in the form of talus or geomorphic formations. F108 apparently used a small cave near an abandoned phosphate mine as a den. The den could not be positively confirmed becaused kittens were not observed, but F108 was located at or near this cave from 3 June to 26 July 1982. Females known not to be denning were never located at one place for this length of time. F52 used a cavity formed by a fallen snag and rocks on a talus slope as a den. Three kittens, approximately 2 weeks old, were present when her den was located on 17 July 1982.

Bobcat and Canada Lynx Relationships

Five adult Canada lynx, 3 males and 2 females, were instrumented in the Garnet Mountain Range during the study period. Data collected primarily from aerial radio-locations provided information on home range characteristics, movements, and habitat types used. This information served as the data base for evaluating relationships between the 2 species.

Canada lynx maintained larger home ranges than bobcats during all seasons except fall (Fig. 9). Mean seasonal home range sizes for lynx varied from 15 to 60 km2 (overall 133 km2) and those for bobcats varied from 20 to 75 km2 (overall 86 km2). The largest seasonal home ranges for both species were observed during spring when breeding was in progress. Where the 2 occurred sympatrically, overlap between the

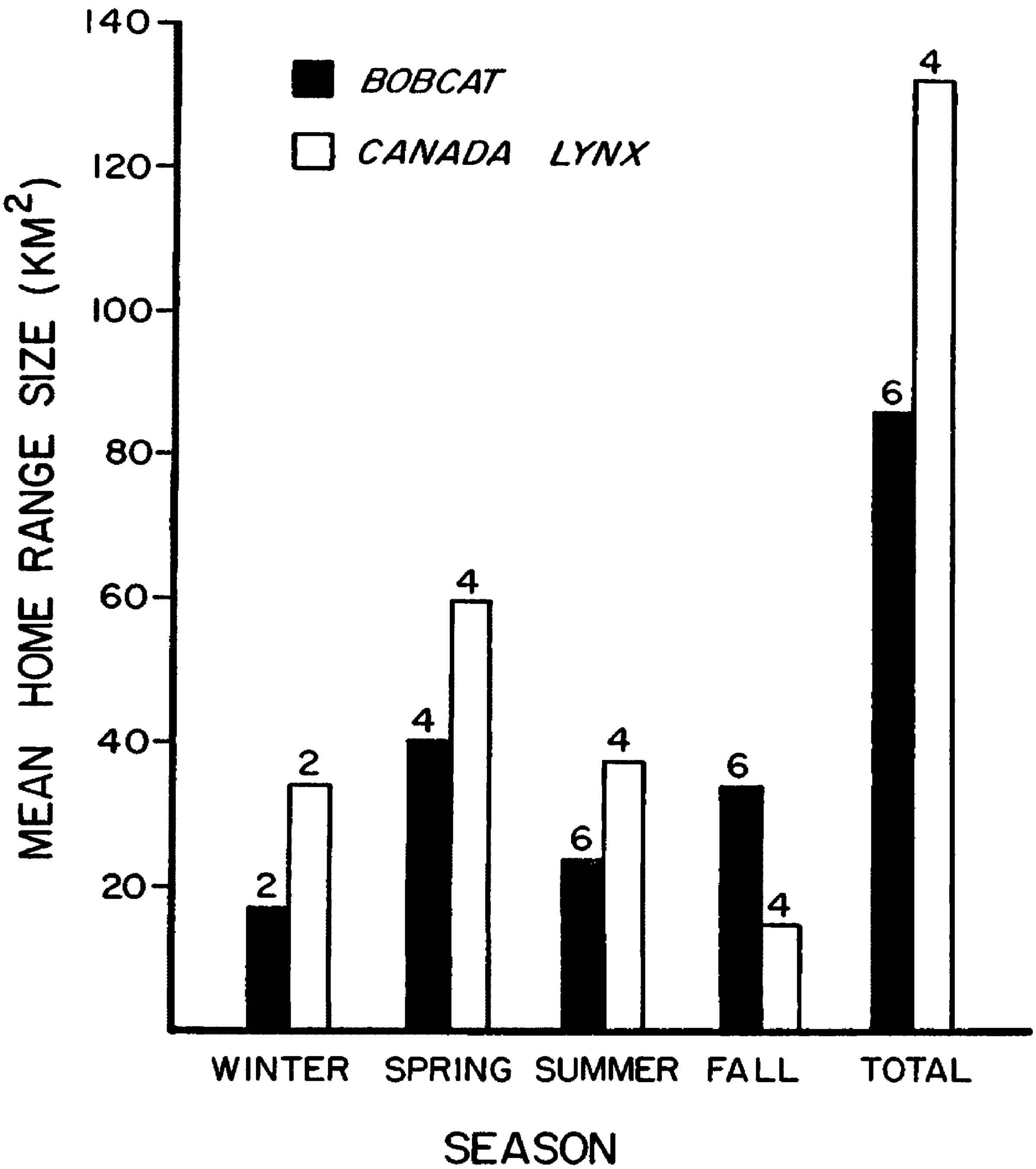

Fig. 9. A comparison of mean home range sizes of adult bobcats and Canada lynx in the Garnet Mountain study area. N = the number of bobcats or Canada lynx used to calculate mean home range size.

species was extensive (Figs. 10 and 11). As much as 95% of bobcat M102's total home range was overlapped by the ranges of lynx M103 and M104. Seasonally, this varied from 0% in winter to 89% in spring. Individuals, however, seemed to maintain separation both spatially and temporally.

Bobcats occupied home ranges at elevations significantly lower than lynx during winter (Fig. 12). Elevations of home ranges were in spring through fall the same for both species, although summer and fall elevations were nearly different at the 0.05 level of significance. Species separation, therefore, appeared to be maintained spatially in winter and possibly during summer and fall when relatively little (12.5 and 31.6%) home range overlap was observed (Fig. 11). In spring, temporal spacing appeared to account for species separation through avoidance (Fig. 13). A measure of the spatial relationship (Clark and Evans 1954) between the spring locations of bobcat M102 and Canada lynx M103 and M104 showed a significant ($p<0.05$) departure from randomness in the direction of unformity or maximum spacing.

In comparing the movements of bobcats and lynx, only movements determined for consecutive radio-locations of 14 days or less were considered. The distribution of distances (Table 14) between consecutive locations of bobcats did not differ significantly from those of lynx ($X2 = 5.83$, $df = 4$, $p > 0.05$). An exceptionally long movement of 96.5 km by lynx M104 and the 1 noted earlier for bobcat M102 were excluded from this analysis. M104 was reported as trapped in December of 1981 near Lolo Peak, 28 km southwest of Missoula.

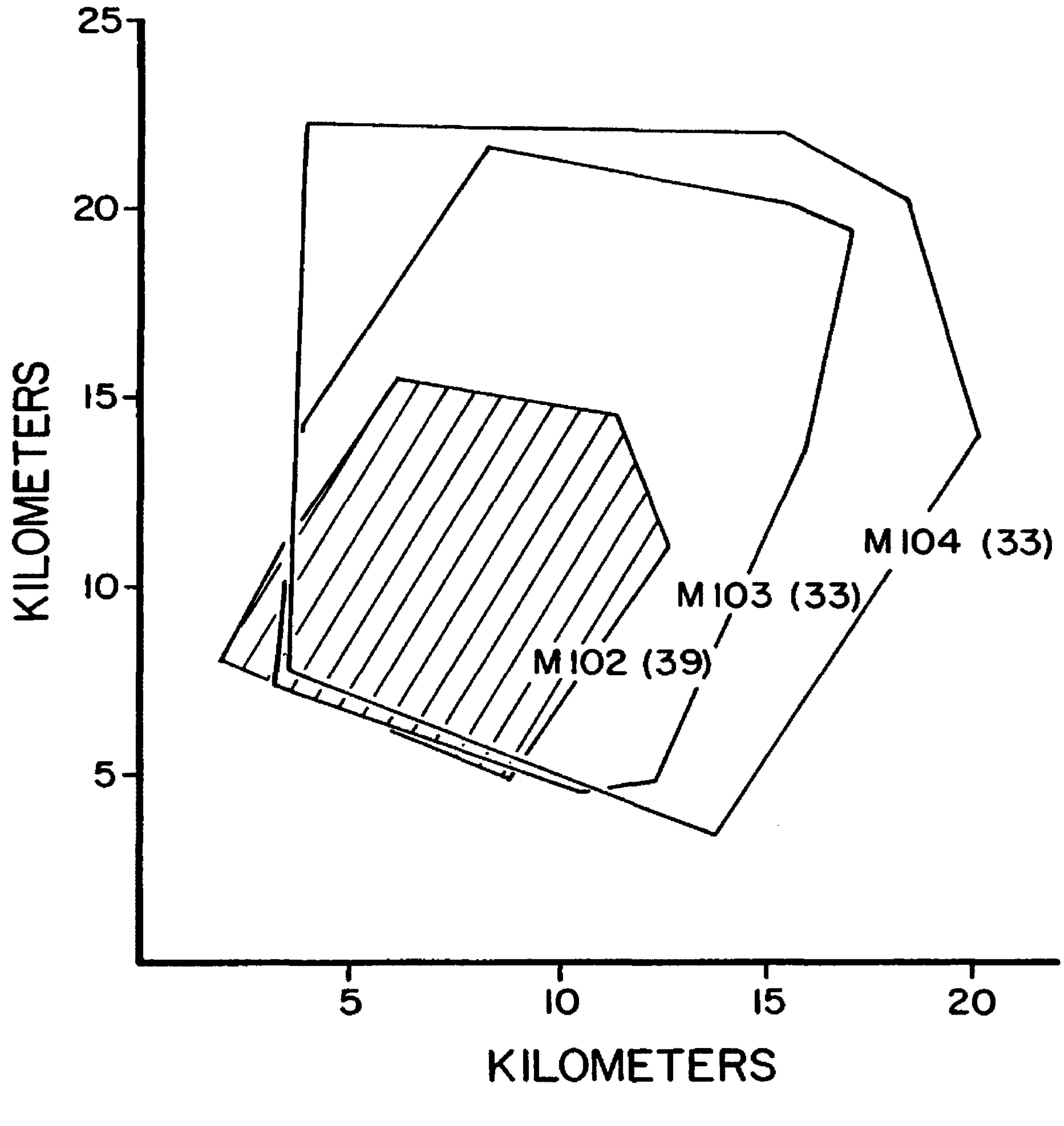

Fig. 10. Spatial distribution of an adult bobcat M102 (shaded) and 2 adult Canada lynx M103 and M104 total home ranges during 1981 in the Garnet Mountain study area. (N) = the number of radio-locations used to estimate total home ranges.

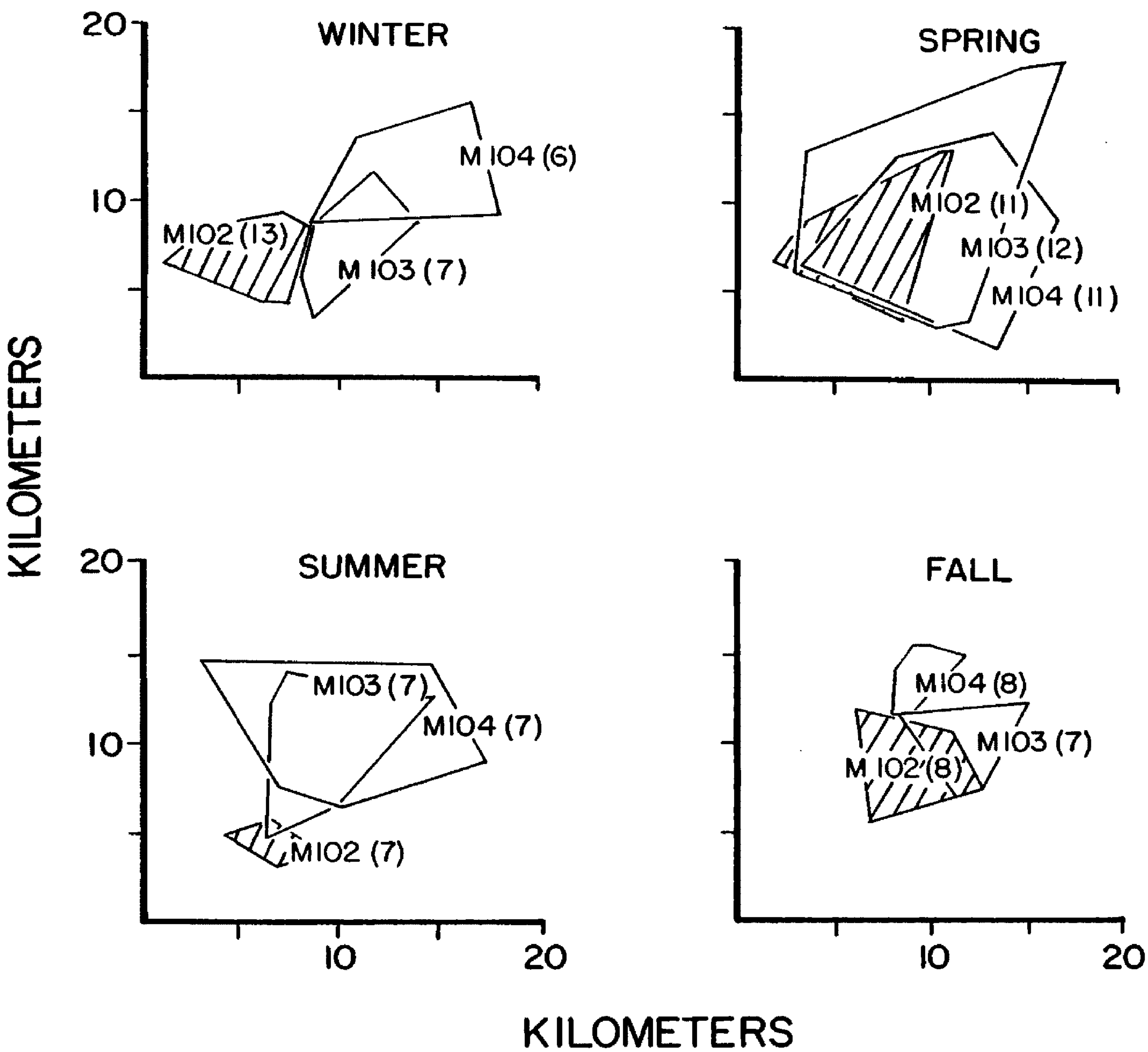

Fig. 11. Spatial distribution of an adult bobcat M102 (shaded) and 2 adult Canada lynx M103 and M104 seasonal home ranges during 1981 in the Garnet Mountain study area. (N) = the number of radio-locations used to estimate seasonal home ranges.

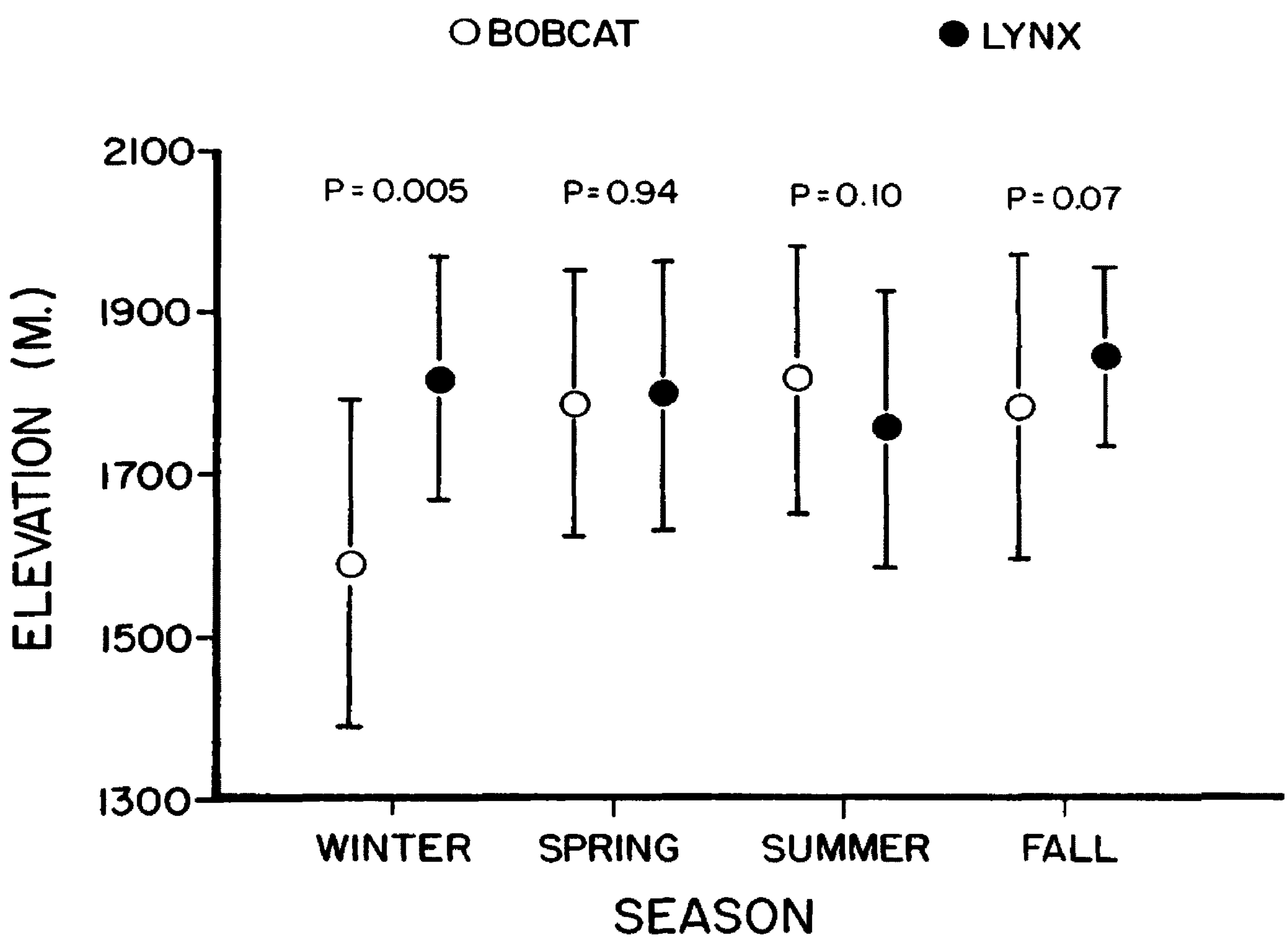

Fig. 12. Mean seasonal elevations and standard deviations of bobcat and Canada lynx radio-locations in the Garnet Mountain study area.

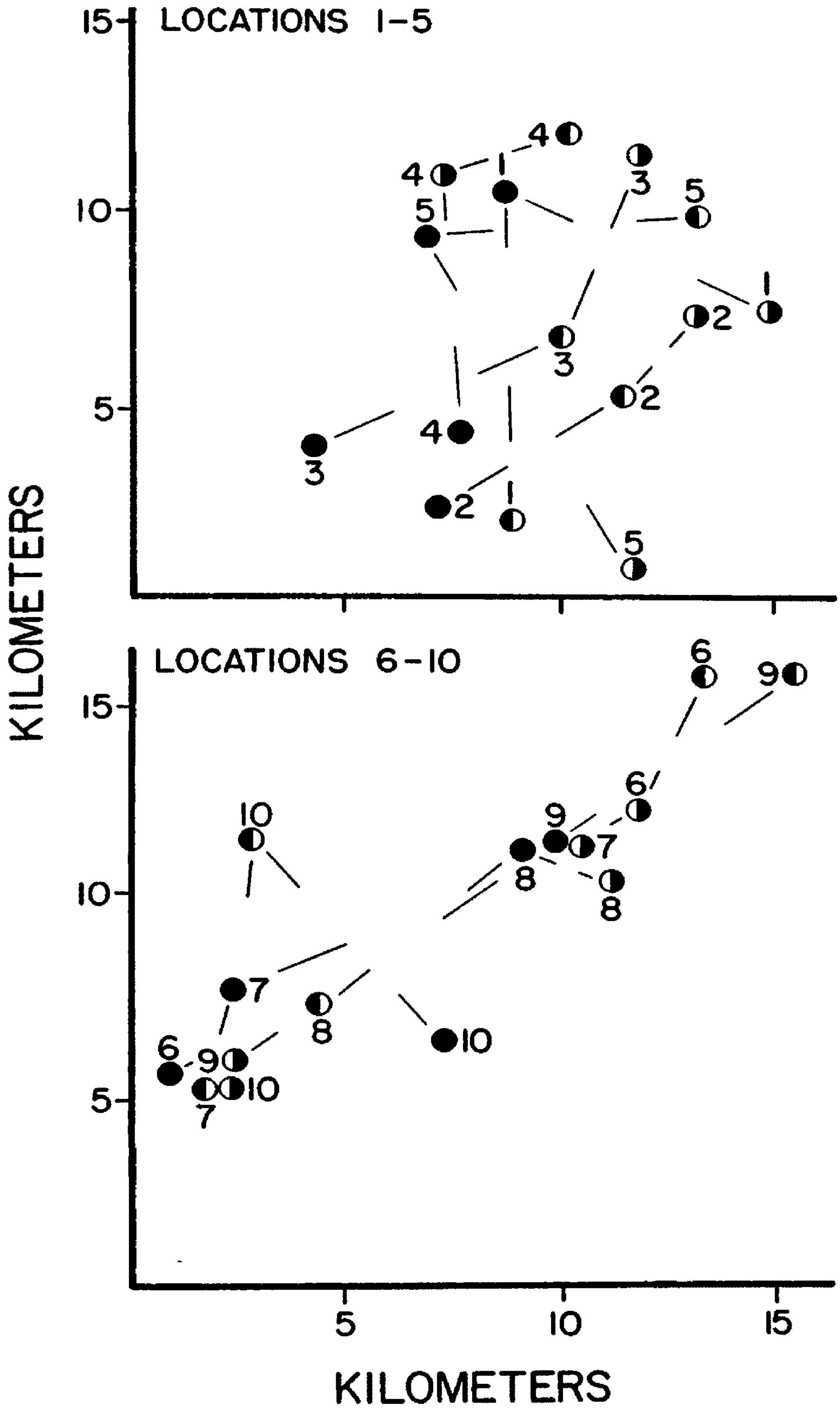

Fig. 13. Spatial relationship among 10 simultaneous radio-locations of adult bobcat M102 (●), lynx M103 (◐), and lynx M104 (◑) during spring of 1981.

Table 14. Distribution of distances between consecutive radio-locations of 14 days or less between adult bobcats and Canada lynx in the Garnet Mountain study area.

Species	Number of Locations 0-1 (km)	1-3 (km)	3-6 (km)	6-9 (km)	> 9 (km)	Total	Average
Bobcat	19	36	50	20	14	139	4.3
Lynx	8	31	43	24	6	112	4.6
Totals	27	67	93	44	20	251	

The percentages of bobcat and Canada lynx radio-locations related to climax habitat type series indicate considerable difference in habitat preference (Fig. 14). Lynx appeared to favor the *Abies lasiocarpa* climax series throughout the year, while bobcats were found most often in the *Pseudotsuga menziesii* climax series. This observation coincides with the elevational shift noted above, because subalpine fir is primarily restricted to high elevations, while Douglas-fir occurs at the low to mid-elevations.

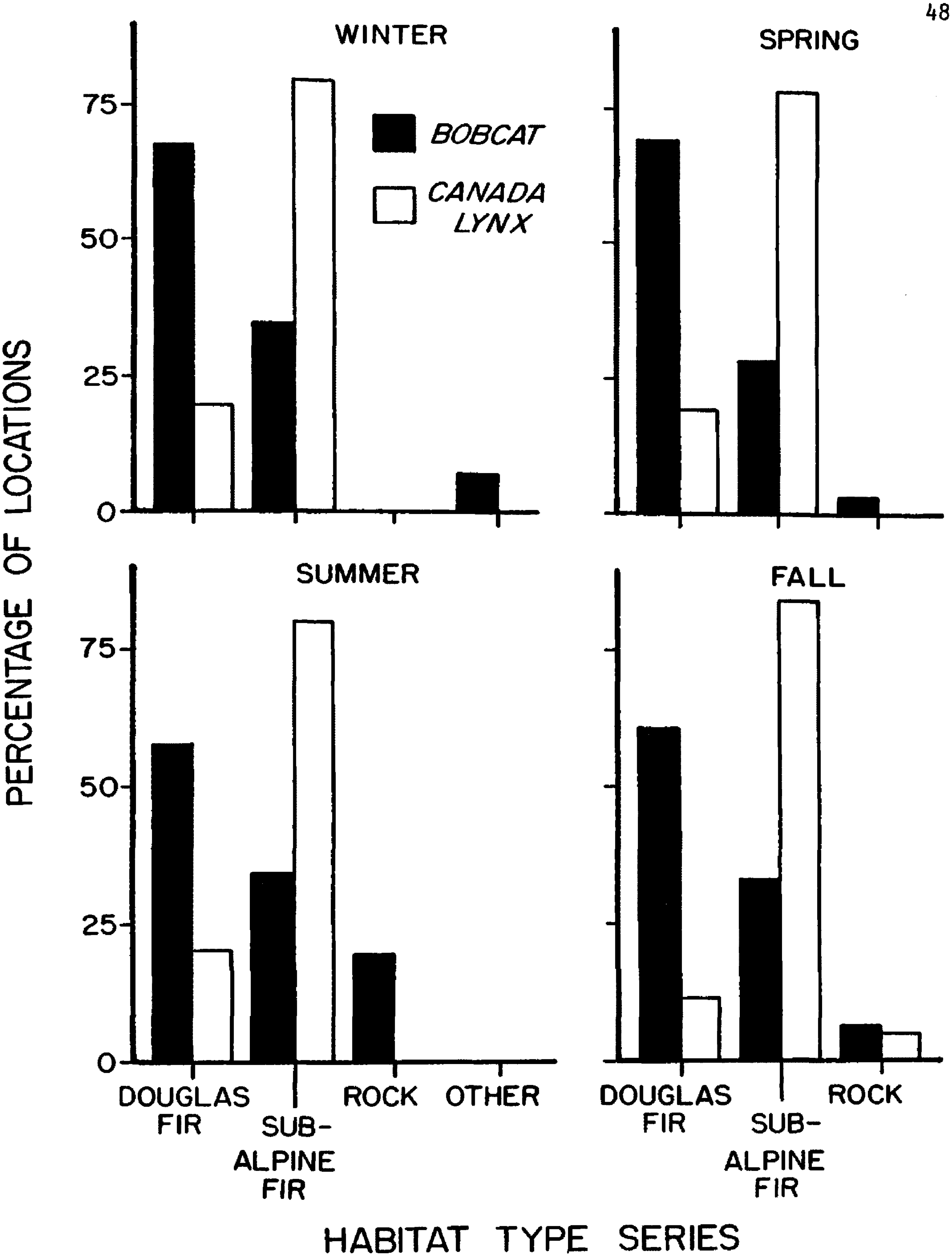

Fig. 14. A comparison of percentages of accurately fixed bobcat and Canada lynx radio-locations by habitat type series (Pfister et al. 1977).

DISCUSSION

Adult bobcat home range size and movement differences based on sex showed females to have larger ranges and to be more mobile than males, but most previous studies have shown the reverse to be true (Table 15). Bailey (1974) concluded that home ranges and movements of females were restricted because they alone raised the family. Thus, most of the female´s time is spent protecting and providing food for her kittens in localized areas. Males, in contrast, have no family-rearing responsibilities and thus greater mobility and larger home ranges. Male home ranges and mobility during this study were probably substantially underestimated because only 2 were tracked, both were extremely old, and 1 could not be located for nearly 2 months. Nevertheless, males and females did exhibit similar seasonal home range size differences in that the largest ranges occurred in spring and the smallest in summer. Larger spring home ranges in both sexes is probably due to the mobility needed for mate location during the spring breeding season. During summer in contrast, at least in females, individuals known or thought to be rearing kittens generally restricted their movements to localized areas, seldom moving more than 2-3 km for several months. Berg (1979) reported similar findings in northern Minnesota as did Knowles (1981) in north-central Montana.

The home ranges reported were larger than observed elsewhere in the United States (Table 15), with comparable sizes documented only in northern Minnesota (Berg 1979). The explanation often given for these differences is regional variations in prey densities. Low prey

Table 15. Adult bobcat home range sizes and movements reported in the United States by region and in order of decreasing size. Original values were converted to like units.

Region/ Location	Season	Home Range Size in Km^2 $\bar{X}$(Range)/Number of Bobcats: F	Home Range Size in Km^2 $\bar{X}$(Range)/Number of Bobcats: M	Movements in Km $\bar{X}$(Range)/Number of Bobcats: F	Movements in Km $\bar{X}$(Range)/Number of Bobcats: M	Source
Northwest						
Montana	Winter	19.5(11.4- 27.6)/2	(22.7)/1	5.7(4.2- 7.1)/1	3.2(0.9- 6.0)[1]/1	This Study
	Spring	31.5(2.6- 56.7)/5	(43.2)/1	4.2(0.4-10.4)/5	4.7(0.9- 8.9)/1	
	Summer	21.2(6.6- 45.9)/6	11.1(6.3- 15.9)/2	3.2(0.0-12.3)/6	3.8(0.9- 6.5)/2	
	Fall	33.6(16.8- 74.2)/6	20.4(14.5- 26.2)/2	5.3(0.5-12.5)/6	4.0(0.3- 8.6)/2	
	Total	88.2(50.1-147.8)/6	63.0(55.0- 70.9)/2	4.0(0.0-12.5)/6	3.9(0.3- 8.9)[1]/2	
Montana	Winter	(13.5)/1	(46.4)/1	1.1/1	---	Knowles (1981)
	Spring	(5.1)/1	(55.2)/1	1.5/1	4.7/1	
	Summer	(7.8)/1	(40.4)/1	0.4/1	5.5/1	
	Fall	(11.7)/1	(61.8)/1	1.0/1	4.5/1	
	Total	(17.8)/1	(83.3)/1	1.1/1	4.9/1	
Idaho	Total	19.3(9.1-45.3)/8	42.1(6.5-107.9)/4	1.2/8	1.8/4	Bailey (1972, 1974)
Washington	Total	(3.9- 8.4)	(6.5- 15.5)	---	---	Brittell et al. (1979)
Northeast						
Minnesota	Total	38.0(15.0- 92.0)/6	62.0(13.0-201.0)/15	2.6/6	4.3/15	Berg (1979)
Southeast						
Tennessee	Winter-Summer	11.5(9.9- 13.1)/2	(42.9)/1	1.2/2	4.5/1	Kitching and Story (1979)
S. Carolina	Fall	(9.4)/1	20.8(16.8- 22.8)/3	(6.5)/1	7.4(6.5- 8.0)/3	Buie et al. (1979)
	Winter	10.4(6.1- 15.8)/3	20.8(12.6- 26.5)/3	6.2(5.3- 7.0)/3	9.9(9.1-12.1)/3	
S. Carolina	Spring-Summer	(4.6)/1	---	2.6(0.8- 4.5)/1	4.8(4.0- 5.6)/1	Marshall (1969)
Louisiana	Summer	1.0(0.8- 1.2)/3	4.9(3.4- 7.3)/3	2.9(0.6- 4.6)/3	4.4(1.8- 6.8)/3	Hall and Newsom (1978)
Alabama	Total	1.1/6	2.6/6	---	---	Miller and Speake (1979)

[1]Excludes an exceptionally long movement of 64.4 km.

densities, though not quantified in this study, may partly explain the large home ranges of instrumented bobcats I observed. A further possibility is that available prey were not uniformly distributed throughout harsher northern environments but were localized in widely separated areas of favorable environments. Movements of bobcats between these areas would, therefore, tend to increase home range size.

The erratic and often extensive movements of juvenile bobcats observed in this study appeared to be characteristic of dispersing animals. Bailey (1972), in describing the social organization of bobcats in Idaho, concluded that the presence of a resident adult prevented other cats of like sex from occupying the same area. Dispersing individuals, therefore, in areas where most suitable home ranges were already occupied, would be forced to move extensively to locate a vacancy. Seidensticker et al. (1973) concluded that the mobility of dispersing mountain lions allowed them to assess the availability of vacant space. The extensive movements of F3 and F107 may have occurred for a similar reason.

The significance of this behavior in bobcats appears, in part, to be a means of population regulation. Occupation of the area in which juvenile F3 was released by resident F1 appeared to preclude her from settling in the area. F3 dispersed out of this area, traveling widely until she located the vacant area to the north of F1 and established a home range. This suggests that in environments where all inhabitable areas were already filled no recruitment to the population would occur. Under such conditions recruitment can only occur as old animals are removed from the population.

Habitat use by radio-collared bobcats was quite variable in this study, but a few patterns were apparent. Bobcats consistently used lower slopes and lower elevations during winter, and in spring through fall, use was generally greater than expected for higher elevations and upper slope positions. This shift probably occurred because of bobcat avoidance of snow depths greater than 15 cm (Marston 1942, McCord 1974). Therefore, bobcats are forced to use the lower elevations along stream bottoms, south and west facing slopes, and foothill areas where snow depths are usually below 15 cm during most of the winter. Habitat type use on each study area also reflects this seasonal elevational shift.

Use of the 6 designated cover types appeared related to the presence of an understory layer or an extensive rock understory feature. Two of the 3 dominant cover types used on an annual basis had an understory of either dense shrubs or forbs and grasses, and the third a primarily rock understory. The importance of this layer becomes evident when seasonal trends were taken into consideration. Winter use was entirely dominated by those cover types that had at least a partial understory layer above existing snow levels. During spring through fall, use of some of these types continued at disproportionately high levels. This probably occurred because of the density of the understory layer they provide. McCord (1974) concluded that the stealthy, secretive hunting technique of bobcats may dictate the need to hunt in relatively dense cover. Therefore, concealment may have been a major factor in cover type use. Prey densities may also have been involved, but no data were collected to allow comparisons of prey densities between cover types.

Extensive rock in the form of talus or geomorphic formations appear to be important during the summer denning season. Two dens were located during the summer of 1982 in steep, inaccessible rocky habitats where the possibility of disturbance was minimal. In Idaho, Bailey (1979) also found most natal and auxiliary dens located in rocky areas. Such habitats may be necessary for successful reproduction.

Bobcat and Canada lynx appeared able to coexist in the Garnet Mountain Range by differences in habitat preference and by some unknown mechanism of avoidance. Analysis of habitat type use showed bobcats favor the Pseudotsuga menziesii series and lynx the Abies lasiocarpa series. Such differences probably served to provide the primary means of species separation because of the seasonal consistency observed. However, it was also apparent from this analysis that habitat preference alone did not account for species separation at all times. From a spatial analysis of bobcat and lynx dispersal patterns during the spring period of extensive range overlap, mutual avoidance behavior also appeared to be involved. Seidensticker (1976) found similar reasons for the coexistence of tigers (Panthera tigris) and leopards (P. pardus) in Nepal, but was unable to determine the avoidance mechanism used.

One possible mechanism by which bobcats and Canada lynx could have avoided each other is through and interactive olfactory marking system. Hornocker (1969) and Seidensticker et al. (1973) observed that scent marking by mountain lions maintained spacing, in time and space, thereby preventing chance encounters. A similar situation occurred in bobcats in southeast Idaho (Bailey 1972,1974). In lynx, mutual avoidance via scent marking has never been demonstrated. However, Saunders (1963) observed that males and females preferentially defecated and urinated at certain spots within their ranges.

MANAGEMENT IMPLICATIONS

1. Areas of local population depletion may occur when trapping seasons coincide with heavy snowfall that cause bobcats to shift to low elevations. Such depletions are probably temporary given the extensive movements observed in dispersing cats. However, successive years of heavy snowfall coupled with the bobcats relatively low reproductive rate could severely reduce the ability of depleted populations to recover. Harvest levels, therefore, should be monitored closely to detect unusual declines that may signal a need to alter management strategies.
2. Rocky habitats in undisturbed areas appear to be a primary source of den sites and should be protected to ensure population integrity. Logging, road construction, and similar disturbances near these areas could reduce the available denning areas with a high degree of security and, in turn, reduce bobcat productivity. Further research should be conducted to determine if other habitats are used as den sites and the level of disturbance that would adversely impact productivity.
3. Reduction of the overstory canopy to less than 50% may reduce the overall habitat available to bobcats. Silvicultural techniques that maintain or promote rapid regrowth of understory vegetation should be considered in planning logging activities.

REFERENCES CITED

Bailey, T.N. 1972. Ecology of bobcats with special reference to social organization. Ph.D. Thesis. Univ. Idaho., Moscow. 82pp.

__________. 1974. Social organization in a bobcat population. J. Wildl. Manage. 38:435-446.

__________. 1979. Den ecology, population parameters and diet of eastern Idaho bobcats. Pp. 62-69. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series 6. 137pp.

Berg, W.E. 1979. Ecology of bobcats in northern Minnesota. Pp. 55-61. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series 6. 137pp.

Bohne, J.R. 1974. Food habits, seasonal distribution, and habitat utilization of elk in the South Fork of Fish Creek, Lolo National Forest, Montana. M.S. Thesis. Univ. Mont., Missoula. 187pp.

Brittell, J.D., S.J. Sweeney, and S.T. Knick. 1979. Washington bobcats: diets, population dynamics and movements. Pp. 107-110. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series 6. 137pp.

Brown, G.W. 1974. Distribution and population characteristics of bighorn sheep near Thompson Falls in northwestern Montana. M.S. Thesis. Univ. Mont., Missoula. 134pp.

Buie, D.E., T.T. Fendley, and H. McNab. 1979. Fall and winter home ranges of adult bobcats on the Savannah River Plant, South Carolina. Pp. 42-45. in Bobcat Research Proc. Natl. Wildl. Fed., Sci. and Tech., Series 6. 137pp.

Buttrey, G.W. 1979. Food habits and distribution of the bobcat, *Lynx rufus rufus* (Schreber), on the Catoosa Wildlife Management Area. Pp. 87-91. in Bobcat Research Proc. Natl. Wildl. Fed., Sci. and Tech., Series 6. 137pp.

Clark, P.J. and F.C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology 35:445-453.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33:43-66.

Ellison, R.L. 1974. Cooperative elk-logging study. Job II-D, Chamberlain Creek study. Pg. 105-125. Ann. Prog. Rpt. January 1 - December 31, 1973. Bur. Land Manage., Missoula, Mont.

Gashwiler, J.S., W.L. Robinette, and O.W. Morris. 1960. Foods of bobcats in Utah and eastern Nevada. J. Wildl. Manage. 24:226-229.

Hall, H.T. and J.D. Newsom. 1978. Summer home ranges and movements of bobcats in bottomland hardwoods of southern Louisiana. Proc. Ann. Conf. Southeastern Assoc. Fish Wildl. Agencies. 30:427-436.

Harestad, A.S. 1981. Computer analysis of home range data. B.C. Fish and Wildl. Branch Bull. B-11. 25pp.

Hornocker, M.G. 1969. Winter territoriality in mountain lions. J. Wildl. Manage. 33:457-464.

Karpowitz, J.F. and J.T. Flinders. 1979. Bobcat research in Utah-a progress report. Pp. 70-73. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series. 6. 137pp.

Kitchings, J.T. and J.D. Story. 1979. Home range and diet of bobcats in eastern Tennessee. Pp. 47-52. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series 6. 137pp.

Knowles, P.R. 1981. Habitat selection, home range size, and movements of bobcats in north-central Montana. M.S. Thesis. Univ. Mont., Missoula. 55pp.

Lemke, T.O. 1975. Movement and seasonal ranges of the Burdette Creek elk herd, and an investigation of sport hunting. M.S. Thesis. Univ. Mont., Missoula. 127pp.

Lyon, L.J. 1973. Cooperative elk-logging study. Job II-A, Burdette Creek-Deer Creek vegetation analysis. Pg. 7-25. Ann. Prog. Rpt. January 1 - December 31, 1972. Forest Sci. Lab., Univ. Mont., Missoula, Mont.

Marcum, C.L. and D.O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. J. Wildl. Manage. 44:963-968.

Marshall, A.D. 1969. Spring and summer movements and home ranges of bobcats in the coastal plain of South Carolina. M.S. Thesis. Univ. Georgia, Athens. 52pp.

Marston, M.A. 1942. Winter relations of bobcats to white-tailed deer in Maine. J. Wildl. Manage. 6:328-337.

McCord, C.M. 1974. Selection of winter habitat by bobcats (Lynx rufus) on the Quabbin Reservation, Massachusetts. J. Mammal. 55:428-437.

Miller, D.S. and D.W. Speake. 1979. Progress report: demorgraghy and home range of the bobcat in south Alabama. Pp. 123-124. in Bobcat Research Proc., Natl. Wildl. Fed., Sci. and Tech. Series 6. 137pp.

Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrenner, and D.H. Bent. 1975. Statistical package for the social sciences. 2nd ed. McGraw Hill, New York. 675pp.

Pfister, R.D., B.L. Kovalchik., S.F. Arno, and R.C. Presby. 1977. Forest habitat types of Montana. Intermountain For, and Range Exp. Sta. USDA For. Ser. Gen. Tech. Rep. INT-34. 174pp.

Pollack, E.M. 1951. Food habits of the bobcat in the New England states. J. Wildl. Manage. 15:209-213.

Progulske, D.R. 1955. Game animals utilized as food by the bobcat in the southern Appalachians. J. Wildl. Manage. 19:249-253.

Robinson, W.B. and E.F. Grand. 1958. Comparative movements of bobcats and coyotes as disclosed by tagging. J. Wildl. Manage. 22:117-122.

Saunders, J.K. 1963. Movements and activities of the lynx in Newfoundland. J. Wildl. Manage. 27:391-400.

Scott, M.D. 1978. Elk habitat selection and use on a undisturbed summer range in western Montana. M.S. Thesis. Univ. Mont., Missoula. 98pp.

Seidensticker, J. 1976. On the ecological separation between tigers and leopards. Biotropica 8:225-234.

_______________, M.G. Hornocker, W.V. Wiles, and J.P. Messick. 1973. Mountain lion social organization in the Idaho Primitive Area. Wildl. Monogr. 35. 60pp.

Southwood, T.R.E. 1966. Ecological methods. Methuen and Co., Ltd., London. 391pp.

Stickel, L.F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal. 35:1-15.

Tilton, M.E. 1977. Habitat selection and use by bighorn sheep (Ovis canadensis) on a northwestern Montana winter range. M.S. Thesis. Univ. Mont., Missoula. 121pp.

Zahn, H.M. 1974. Seasonal movements of the Burdette Creek elk herd. M.S. Thesis. Univ. Mont., Missoula. 71pp.